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MEMORANDUM FOR: R. Dale Smith, Chief
Low-Level Waste Licensing Branch
Division of Waste Management

FROM: Timothy C. Johnson
Low-Level Waste Licensing Branch
Division of Waste Management

SUBJECT: CURIUM-242

Enclosed is an evaluation to determine an acceptable concentration for Cm-242 for disposal at near-surface disposal facilities. This evaluation should be docketed under our 10 CFR 61 rulemaking activity in accordance with our policy for preparing technical evaluations.

Original Signed By

Timothy C. Johnson
Low-Level Waste Licensing Branch
Division of Waste Management

Enclosure:
As stated

OFFICE	WMLL						
SURNAME	TJohnson:jh						
DATE	02/25/82						

EVALUATION OF Cm-242 CONCENTRATION FOR DISPOSAL

Purpose: The purpose of this evaluation is to determine an acceptable concentration for disposing of wastes containing short-lived Curium 242 in near-surface disposal facilities.

Reference:

1. Proposed rule, 10CFR61, "Licensing Requirements for Land Disposal of Radioactive Waste," Federal Register, Vol. 46, No. 142, July 24, 1981, Table 1, p. 38097.
2. Draft Environmental Impact Statement on 10CFR61, "Licensing Requirements for Land Disposal of Radioactive Waste," NUREG-0782, Vol. 2 , p. 7-16.
3. Radiological Health Handbook, U.S. Department of Health, Education, and Welfare. Revised Edition, Jan. 1970 pp. 28-29.
4. Table of Isotopes by C.M. Lederer, J.M. Hollander, and I. Perlman, Sixth Edition, pp 144, 147.

Results: Near-surface disposal of Cm-242 exceeding 10 nCi/g would be acceptable to NRC staff, if the upper concentration limit does not exceed 2 uCi/g. The concentration of the daughter product of Cm-242, Pu-238, would, however, need to be included in the total 10 nCi/g cumulative concentration with the other long-lived alpha-emitting TRU nuclides in the wastes.

Evaluation: In Table 1, Draft 10CFR61, an exception of TRU nuclide concentration is listed for Pu-241, a short-lived transuranic which has a long-lived alpha-emitting daughter, Am-241. Using the same rationale provided by Chapter 7 of the Draft Environmental Impact Statement to 10CFR61 (NUREG-0782, Volume 2), we calculate the ratio of the specific activity of Cm-242 to Pu-238 to be about 200. The upper concentration limit for Cm-242 is recommended to be 2 uCi/g (See Appendix I).

Furthermore, Cm-242 is a short-lived isotope (163 days). By the time the 100 year institutional control period ends, any Cm-242 disposed of in a near surface disposal facility will be negligible. (See Appendix II).

Calculated by R. T. Lee Date 2-19-82

Checked by [signature] Date 2-23-82

Approved by [signature] Date 2/23/82

Appendix I. (From Reference 3):

Specific Activity

The rate of decay per gram or specific activity is equal to λN and

$$\lambda N = 0.693 N/T\ 1/2 = \text{dis/sec/gm}$$

where T 1/2 = half-life (seconds)

N = Number of atoms per gram

λ = Decay constant (1/seconds)

$$\text{Number of atoms per gram for Cm-242} = \frac{6.02 \times 10^{23}\ \text{atom/mole}}{242.05\ \text{g. mole}}$$

Therefore,

$$N_{Cm\text{-}242} = 2.49 \times 10^{21}\ \text{atom/g} \qquad (1)$$

$$\text{Number of atoms per gram for Pu-238} = \frac{6.02 \times 10^{23}\ \text{atom/mole}}{238.04\ \text{g. mole}}$$

Therefore,

$$N_{Pu\text{-}238} = 2.53 \times 10^{21}\ \text{atoms/g} \qquad (2)$$

Since the half life of Cm-242 is 163 days (Reference 4) and the half life of Pu-238 is 86 years (Reference 4), the ratio of specific activity of Cm-242 to Pu-238 is:

$$\frac{\dfrac{0.693 \times \text{No. of atoms per gram of Cm-242}}{\text{half-life (seconds) of Cm-242}}}{\dfrac{0.693 \times \text{No. of atoms per gram of Pu-238}}{\text{half-life (seconds) of Pu-238}}} \qquad (3)$$

Substituting (1) and (2) into equation (3), we get:

$$\frac{\dfrac{0.693 \times 2.49 \times 10^{21}\ \text{(atoms/g)(365 day/yr)}}{163\ \text{(days)} \times 86400\ \text{(sec/yr)}}}{\dfrac{0.693 \times 2.53 \times 10^{21}\ \text{(atoms/g)}}{86\ \text{(yrs)} \times 86400\ \text{(sec/yr)}}} \qquad (4)$$

Reducing equation (4) yields:

$$\frac{2.49 \times 10^{21} \text{ (atoms/g) } 365 \text{ (days/yr) } 86 \text{ (yr)}}{2.53 \times 10^{21} \text{ (atoms/g) } 163 \text{ (days)}} = 190$$

Due to the inaccuracies of measuring TRU nuclides, we round off this value to 200. Therefore, to compute the specific activity of Cm-242 to produce 10 nCi/g of Pu-238, we multiply the ratio of specific activities (200) times 10 nCi/g (the long-lived TRU limit) to get 2 uCi/g for Cm-242. Therefore, a waste with 2 uCi/g of Cm-242 will decay to 10 nCi/gm of Pu-238.

Appendix II

In order to show that Cm-242 will have negligible effect after disposal, we use the decay equation to compute the Cm-242 activity at the time institutional control over the disposal site is assumed to be lost. We assume that the institutional control period is 100 years. Therefore,

$$I = I_o \, e^{-0.693 \, t/T \, 1/2}$$

where I_o = Cm-242 activity at some original time

I = Cm-242 activity after a time interval, t

$T\,1/2$ = Half-life of a particular radioactive element

t = Period of decay, years

After 100 years institutional control:

t = 100 years

$T\ 1/2$ of Cm-242 = 163 days

$$I = I_o \, e^{\frac{-0.693 \times 100 \text{ (yr)} \times 365 \text{ (days/yr)}}{163 \text{ (days)}}}$$

$$\frac{I}{I_o} = 4.0 \times 10^{-68}$$

Therefore, after 100 years only 4.0×10^{-68} of the initial Cm-242 activity will remain. Therefore, its activity after the institutional control period will be negligible assuming that only uCi amounts of Cm-242 are initially present.