DISPOSAL OF THORIUM AND URANIUM WASTES

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INTRODUCTION

Some of the sites formerly used for processing thorium and uranium in the United States are known today to be contaminated with residual radioactive materials. In many cases, the total amount of contaminated soil is large, but the activity concentrations of radioactive materials present are sufficiently low as to justify their disposal on privately owned lands or storage onsite rather than transport them offsite to a licensed radioactive materials disposal (commercial) site. In many instances, packaging and transporting these wastes to a licensed disposal site would be too costly and not justified from the standpoints of risk to the public health or cost-benefit.

The U.S. Nuclear Regulatory Commission (USNRC) in late 1981, issued a Branch Technical Position which discussed options for approving license applications for disposal of uranium and thorium under USNRC regulations. In the following sections, the technical bases, rationale and dose calculations for establishing the limiting concentrations in wastes under each disposal option are discussed. The Branch Technical Position has been used since 1981 for reviewing the acceptability of disposal methods proposed by U.S. organizations.

DISPOSAL AND STORAGE OPTIONS

The following describes the established disposal and storage options for uranium and thorium wastes. A summary of the maximum concentrations permitted under each disposal option is provided in Table I.

1. Disposal of acceptably low concentrations of natural thorium, depleted or enriched uranium, and uranium ores with no restriction on burial method.

The concentrations specified for this option are believed acceptably low without restricting the method of burial. It is expected, however, that facility operations will be conducted in such a manner as to minimize the possibility of soil contamination and when such occurs the contamination will be reduced to levels as low as reasonably achievable.

2. Disposal of certain low concentrations of natural thorium and depleted or enriched uranium (with essentially no daughters present) when buried under prescribed conditions with no land use restrictions and no continuing NRC licensing of the material.

Under this option, burial will be permitted only if it can be demonstrated that the buried materials will be stabilized in place and not be transported away from the site. Acceptability of the site for disposal will depend on topographical, geological, hydrological and meteorological characteristics of the site. At a minimum, burial depth will be at least four feet below the surface. Also, recorded title documents are expected to state that the specified land contains buried radioactive materials.

3. Disposal of low concentrations of natural uranium ores with daughters in equilibrium, when buried under prescribed conditions in areas zoned for industrial use, and the recorded title documents are amended to state that the specified land contains buried radioactive materials and are conditioned in the manner acceptable under state law to impose a covenant running with the land that the specified land may not be used for residential building. (There is no continuing NRC licensing of the material.)

Disposal will be approved if the burial criteria outlined in Option 2 (including burial at a minimum of four feet) are met. Under this option, no residential building would be permitted over land where natural uranium ore residues have been buried.

4. Disposal of land-use-limited concentrations of natural thorium, natural uranium and depleted or enriched uranium when buried under prescribed conditions in areas zoned for industrial use and the recorded title documents are amended to state that the land contains buried radioactive materials, and are conditioned in the manner required by state law to impose a covenant running with the land that the land (1) may not be excavated below stated depths in specified areas unless cleared by appropriate health authorities, (2) may not be used for residential or industrial building, and (3) may not be used for agricultural purposes. (There is no continuing NRC licensing of the disposal site.)

Criteria for disposal under these conditions is predicated upon the assumption that intentional intrusion is less likely to occur if appropriate warnings are given in land documents of record. In addition to meeting the burial criteria in Option 2, recorded title documents must be amended to impose these land use restrictions. Also, it is expected that disposal under this option will normally be approved only if disposal is carried out on publicly owned land.

5. Storage of licensed concentrations of thorium and uranium onsite pending the availability of an appropriate disposal site.

When concentrations exceed those specified in Option 4 disposal is normally carried out on publicly owned land, which is subject to continuing monitoring and government inspection. For an interim period, thorium and uranium may be stored onsite under an NRC license until a suitable method of disposal is found.

DOSE LIMITS FOR THE DISPOSAL OPTIONS

The dose limits in Option 1 are based on the clean-up guidance from the U.S. Environmental Protection Agency (EPA) for similar situations. For natural uranium, EPA's disposal standard is 5 picocuries of radium 226 per gram of soil at the soil surface and 15 picocuries per gram at soil depths below 15 centimeters. In addition, concentration limits for uranium and thorium were calculated based on limiting the annual intakes from the inhalation and ingestion pathways to maximum doses of 20 millirems to lung and 60 millirems to bone as recommended in an EPA standard for protection against transuranium elements present in the environment. For direct radiation, an external dose limit of 10 microroentgens per hour above background was used. The selection of these dose guidelines was influenced by the NRC policy of maintaining radiation exposures as low as reasonably achievable.

The dose limits in Option 2 are such that (1) no member of the public should receive a radiation dose exceeding those discussed in Option 1 when the wastes are buried in an approved manner absent intrusion into the burial grounds and (2) no member of the public would likely receive a dose in excess of 170 millirems to a critical organ in the event of a possible intrusion into the burial ground.

The dose limit in Option 3 involving the disposal of low level natural uranium wastes (with daughters in equilibrium) is based on appropriately limiting indoor exposure of radon-222 and its daughters. Under the limited land use restriction of this option, no individual will likely be exposed from indoor radon-222 and its daughters to an annual average of 0.5 working level month (WLM).

The dose limit in Option 4 is based on a limited exposure under a restrictive land use requirement such that an individual is not expected to receive a dose in excess of 500 millirems to a critical organ and radon doses will not exceed 0.5 WLM as a result of intruding into the disposal location.

DOSE CALCULATION AND DERIVED MAXIMUM ALLOWABLE CONCENTRATIONS FOR VARIOUS DISPOSAL OPTIONS

From the above dose limits, calculations were performed to derive the concentration limits for each disposal option. With regard to concentration limits based on external exposure, calculations were based on the methodology and dose conversion factors taken from ORNL-4992 "A Methodology for Calculating Radiation Dose from Radioactivity Released to the Environment."

The calculations assumed (1) distribution of radioactive material over an infinite plane (2) a structural shielding factor of 0.5, (3) a maximum occupancy factor of 80 percent and (4) an exposure dose delivered at one meter from the surface.

With regard to concentration limits based on internal exposure, the same methodology as in ORNL-4992 was used. For inhalation, the dose conversion factors for the Task Group Lung Model were taken

from ORNL/ NUREG/TM-190. In the case of inhalation of radon and its daughters, the limiting radium concentrations were based on a radon dose less than that given by continuous exposure to 0.02 working level. The calculations assumed (1) a maximum dry soil density of 2.5 gm/cc, (2) a resuspension factor of $5 \times 10^{-9} m^{-1}$ in the case of airborne particulates and an average particle size of one micron (AMAD=1um), (3) a quality factor of 20 for alpha particles, (4) an occupancy factor of 80 percent and (5) 60 percent of an individual's food intake could be harvested from contaminated soil.

CONCLUSION

The disposal and storage options for uranium and thorium discussed in this paper are believed appropriate to assure proper protection of the general public and are believed also cost effective. The disposal options provide viable and safe alternatives to continued storage of low-level radioactive wastes and permit reuse of land that would otherwise be unavailable for productive purposes.

TABLE 1

SUMMARY OF MAXIMUM CONCENTRATIONS PERMITTED UNDER DISPOSAL OPTIONS

Kind of Material	Disposal Options (pCi/gm) 1[a]	2[b]	3[c]	4[d]
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10	50	--	500[e]
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10	--	40	200[e]
Depleted Uranium				
o Soluble	35	100	--	1000[e]
o Insoluble	35	300	--	3000
Enriched Uranium				
o Soluble	30	100	--	1000[e]
o Insoluble	30	250	--	2500

a. Based on U.S. Environmental Protection Agency (USEPA) cleanup standards.
b. Concentrations based on limiting individual doses to 170 mrem from an annual exposure.
c. Concentrations based on limiting equivalent exposure to 0.02 working level or less.
d. Concentrations based on limiting individual doses to 500 mrems and, in case of natural uranium, limiting exposure to 0.02 working level or less.
e. We are considering limitation of the concentrations of soluble materials to the same concentrations specified in Options 2 and 3 in order to minimize potential leaching of materials into groundwater.