DE MINIMIS APPLICATIONS FOR ALTERNATIVE DISPOSAL OF VERY LOW LEVEL RADIOACTIVE WASTE AT DUKE POWER COMPANY

Changfuh Lan
Duke Power Company
Nuclear Production Department
Charlotte, NC 28242

ABSTRACT

Existing NRC regulations provide no minimum level of radioactivity in waste from a licensee's facility that may be disposed of in a manner other than as radioactive waste. With one exception, in 10CFR§20.306, licensees may dispose of certain levels of tritium and carbon-14 in liquid-scintillation and animal-carcass waste without regard to its radioactivity. In the interim, before specific or generic provisions for disposing of very low level radioactive wastes are adopted through rule making, licensees have another alternative for obtaining approval to dispose of large volumes of materials contaminated with very low levels of radioactivity under provision 10CFR§20.302(a) "Method for obtaining approval of proposed disposal procedures." This paper provides the experiences of obtaining both NRC and states (North Carolina and South Carolina) approval for disposing of very low-level radioactive wastes from Duke Power Company's nuclear stations. The approved disposal procedures include landfarming of water treatment residues, on-site disposal (burial) of sand and feedwater heaters, and offsite release for treatment and disposal of sanitary sewage sludge. In summary, users of radioactive materials should not exclude this approach in their quest to reduce the volume of radioactive waste. It is expected that such submittals could provide a data base for further development of generic limits for radioactive wastes.

INTRODUCTION

Over the last several years considerable attention has been focused on low level radioactive disposal. Limited waste disposal sites capacities, rising costs and political and social pressures are resulting in increased efforts to minimize radioactive waste volumes.

General requirement for waste disposal in provision 10 CFR 20.301 [1] addresses that no licensee shall dispose of licensed material in a manner other than authorized in the regulations. In practice, no radioactive (licensed) material means no detectable radioactive material.

Modern radiation detection equipment can detect and measure radionuclides concentrations in material at very low levels, including very low levels of radioactive contamination in material such as soil, oil, residues, tools and equipment. Existing regulations, 10CFR Part 61 [2], recognize three classes of radioactive waste materials from nuclear power plants that require disposal at licensed facilities. Class A waste is the category with the lowest concentrations of radionuclides, yet it contributes more than 80% of the total volume of waste shipped to disposed sites. It is widely accepted that a significant portion of this waste class contains such a low level of radioactivity that it poses virtually no risk to people or the environment.

There has been considerable interest in developing criteria for disposal of radioactive waste by less restrictive means, often termed "de minimis" waste disposal. As generally accepted, the term de minimis implies a level of radioactivity below which it is not necessary to exercise controls for the purpose of radiological protection. The application of this principle to radiation exposures will not resolve the continuing scientific debate over whether the threshold or non-threshold model of dose-effect relationship is correct. It does mean, however, that the risks to the public associated with exposures to doses of radioactivity below certain levels are so low that there is no value in expending resources to reduce them further, and that wastes so categorized may be disposed of without regard for their level of radioactivity.

BACKGROUND AND HISTORICAL OVERVIEW

In 1983, IE Information Notice 83-05: Obtaining approval for disposing of very-low-level radioactive waste -- 10CFR Section 20.302 [3], was issued by the NRC. It offers to NRC licensees the opportunity to pursue alternative disposal methods until generic provisions for disposing of very low-level radioactive waste can be adopted through a rulemaking. As stated in the information notice:

> "The purpose of this information notice is to bring the provisions of 10 CFR 20.302(a) to the attention of licensees. The NRC staff believes that submittals and approvals in accordance with 10 CFR 20.302(a) can provide a reasonable alternative to high cost disposal by shallow land burial at waste repositories of large volumes of material contaminated at low levels. Such submittals could also provide a data base for further development of regulatory provisions for disposing of specific wastes below some activity level without regard to their radioactivity similar to the provisions of 10 CFR 20.306 for disposing of certain licensed materials containing low levels of carbon-14 and tritium."

The NRC has recently approved alternative methods for disposing of very low-level radioactive wastes at Duke Power Company's nuclear stations. The approved disposal procedures include landfarming of water treatment residues, on site disposal (burial) of sand and feedwater heaters, and offsite release for treatment and disposal of sanitary sewage sludge. These authorizations have been accomplished under the provisions of 10CFR 20.302. For the cases to date, the following is an overview of the NRC's evaluation and bases for the authorization of alternative disposal methods at Duke Power Company.

DISCUSSION

Case 1

By letter dated May 29, 1984, Duke Power Company requested NRC approval pursuant to 10 CFR 20.302 of a proposed procedure for disposal on-site at the Oconee Nuclear Station of slightly contaminated sand. The source of material to be disposed of is sand which was used as the abrasive in the cleaning and decontamination of surfaces by abrasive blasting (sandblasting). The volume of waste sand being generated each year is projected to range from 300 to 1500 cubic feet. The radionuclides in the sand and their average concentrations are Mn-54 0.634 pCi/gm (23.5 mBq/gm), Co-60 1.24 pCi/gm (45.9 mBq/gm), Cs-134 14.9 pCi/gm (551.3 mBq/gm), and Cs-137 36.5 pCi/gm (1.35 Bq/gm). At a density of 120 lb per cubic foot (about 1.9 g/cm^3), 1500 cubic feet of such sand would contain a total of 3.0 mCi (111 mega Bq) Cs-137, 1.2 mCi (44.4 mega Bq) Cs-134, 0.1 mCi (3.7 mega Bq) Co-60 and 0.052 mCi (1.9 mega Bq) Mn-54.

The proposal includes the following procedures and conditions:

(a) For each batch of waste generated, a composite sample from different containers will be taken for radiological analysis, and results will be documented.

(b) The total waste volume and radioactivity inventories will be documented, and the total accumulated dose at the disposal site will be periodically evaluated.

(c) The waste sand contained in the 55 gallon drums (each drum only half full) will be transported by vehicle to the disposal site.

(d) The waste (sand) will be poured into a 7 to 12 foot deep trench at the proposed burial site and covered with approximately 3 feet of uncontaminated soil.

In January 30, 1985, the NRC approved the application and concluded that the disposal procedure is acceptable with the addition of the following requirements:

(1) No batch of waste sand will be buried under this procedure if the sum of the average activity concentrations in it of Cs-134, Cs-137, Co-58, Co-60 and Mn-54 exceeds 150 pCi/gm (5.55 Bq/gm).

(2) Analysis of each batch of waste sand shall be completed and documented, confirming that its average radionuclide concentration is less than 150 pCi/gm, before moving it to the burial location.

(3) Disposal at the Oconee Nuclear Station by this procedure shall be limited to 1500 cubic feet of sand per year.

(4) Measures shall be taken to prevent removal of the sand from the burial location for unauthorized purposes, e.g., sand trucked to the burial location shall be promptly poured in the trench and promptly covered with soil.

Because of the small quantities of material involved, and their ordinary nature, the potential for radiation exposure of workers and the public is the primary concern. The following radiation exposure estimates are based on burial of 1500 cubic feet of sand per year in which the sum of the activity concentrations of Cs-134, Cs-137, Co-58, Co-60 and Mn-54 does not exceed 150 pCi per gram (5.55 Bq/gm). The direct radiation exposure rate from the buried material is estimated to be sufficiently small that a person occupying a spot directly above the buried material for 2000 hours per year would receive a yearly dose less than 1.0 mrem (10 μSv) to the total body.

The proposed burial location due east of the Oconee plant is in an area between the plant and the Keowee River which is totally owned by the licensee and in which the surface water and groundwater both migrate toward the Keowee River. There is no expected impact on either groundwater or surface water usage by the proposed method of disposal, both because of the isolation of the location and because of the small quantity to be buried each year. A drinking water radiation exposure dose is highly unlikely. Table I summarizes the above estimates of annual radiation doses from implementing the proposed disposal procedure.

Table I

Estimated annual radiation doses from implementation of the proposed disposal procedure.

Exposure mode	Dose rate
(1) Public	
External gamma radiation to the total body	≦ 1.0 mrem/year (10 μSv/yr)
Inhalation doses to the total body or to any organ	≦ 0.1 mrem/year (1 μSv/yr)
Ingestion doses (future) to the total body	≦ 1.0 mrem/year (10 μSv/yr)
to any organ (adult)	≦ 2.0 mrem/year (20 μSv/yr)
(2) Nuclear station workers	
External gamma radiation to the total body	≦ 0.07 person-rem/year
Inhalation doses to the total body or to any organ	≦ 0.1 person-rem/year

Pursuant to 10 CFR Part 150, the NRC has delegated the authority to regulate by-product material in the State of South Carolina to the State's Bureau of

Radiological Health. Permission for burial of by-product material in the State of South Carolina must be issued by that agency. In addition, other state and local regulatory agencies may have some jurisdiction in this area.

Case 2

By letter dated June 18, 1984, Duke Power Company requested NRC approval pursuant to 10 CFR 20.302 of a proposed procedure associated with disposal of slightly contaminated water treatment sludge using a landfarming site contiguous to the McGuire Station site. The proposed action was to periodically remove and relocate the sludge consisting of slightly contaminated water treatment residues from the initial holdup pond of the wastewater treatment system and to dispose of this sludge at a state-approved landfarming site contiguous to the McGuire Station site. The sludge (residues) would be spread about six inches deep over a surface area of no more than one acre each year to dry and then incorporated into the underlying six inches of soil. The volume of sludge being generated per year is projected to range from 8,500 to 13,500 cubic feet with a total activity of 0.05 mCi (1.85 mega Bq) of Co-58 and 0.05 mCi (1.85 mega Bq) of Co-60.

The proposed procedures and conditions of disposal are as follows:

(a) For each batch of waste generated, a composite sample from different locations shall be taken for radiological analysis, and results shall be documented and records maintained. The analysis of the sludge shall be obtained before it is transferred, and no batch shall be landspread if its average Co-60 content exceeds 0.5 pCi/cm^3 (18.5 mBq/cm^3).

(b) To remove this sludge, the pond shall be drained and the sludge dredged from the bottom and moved by dump truck to the disposal site.

(c) The sludge shall be transported to or from the disposal site in such a way that liquid or solid spills will be kept to a minimum.

(d) The waste sludge (water treatment residues) shall be spread on the surface of the proposed disposal site over an approximate area and depth of one acre and six inches, respectively.

(e) The sludge shall be incorporated approximately six inches into the soil after drying to the extent practical.

(f) Provisions shall be taken and maintained to prevent wind erosion and surface runoff from conveying pollutants from the waste material application disposal area onto the adjacent property.

(g) Upon retirement, the site shall be covered with topsoil, as necessary to support revegetation, and grassed.

Based on the average specific concentration of 0.12 pCi (4.4 mBq) Co-58 and 0.12 pCi (4.4 mBq) Co-60 per cubic centimeter, the potential gamma radiation exposure from such material is that a person spending 2000 hours per year in an effectively infinite area of such contamination would receive a dose less than 1.0 mrem/year (10 μSv/yr). Incorporating the sludge in the underlying soil and/or covering it with topsoil would, reduce the exposure rate from the contamination. Such an exposure rate is, in any case, insignificant compared to the background exposure from naturally occurring radioisotopes in average soils.

The estimated potential doses from ingestion of vegetables grown in such contamination; the largest potential organ dose would be less than 0.1 mrem/year (1 μSv/yr). For a worker inhaling airborne dust with such contamination levels would receive a maximum dose to the lung much less than 0.1 mrem per year even if exposed 2000 hours per year to ten times the EPA Total Suspended Particulates standard of 260 g/m^3, all respirable. Doses to other internal organs would be smaller.

In November 2, 1984, the NRC approved the application with a provision that no batch shall be landspread if its average Co-60 content exceeds 0.5 pCi/cm^3 (18.5 mBq/cm^3) and concludes that:

(1) The radiation risks to workers involved in the disposal would be small compared to the routine occupational exposures at the McGuire Nuclear Station.

(2) The possible radiation risks to members of the general public as a result of such disposal would be well below regulatory limits and small in comparison to the doses they receive each year from natural background radiation.

Pursuant to 10 CFR 150.15(a)(1), the Commission's regulatory requirements include handling (i.e, dredging and transport) and storage (i.e, landspreading) of radioactive wastes. Disposal aspects of the procedure (i.e., incorporation of the sludge into the soil and covering) are the regulatory responsibilities of Agreement States (i.e, North Carolina Department of Natural Resources and Community Development).

Case 3

By letter dated June 25, 1984, Duke Power Company requested NRC approval for a proposed disposal of sewage sludge containing very low concentrations of radionuclides from Oconee Nuclear Station to a Public Owned Treatment Works. The sludge is contained in the Oconee Sanitary Waste System. The principal radionuclides in the sludge and their average concentrations (pCi/cc) are as follows: Co-58, 0.09; Co-60, 0.17; Cs-134, 0.08; and Cs-137, 0.28. The approximate volume of the sludge is 4000 cubic feet. Since the biological materials in the sludge are potentially more hazardous than the radionuclides, Duke Power Company proposes to dispose of the sludge by transferring it as non-contaminated material to a vendor who would then transport it to a Publicly Owned Treatment Works. At the Treatment Works the sludge will be placed in an anerobic digester or aerated lagoon where it will be diluted with substantial quantities of sludge from other sources, and then dried. The dried and diluted sludge would then be transferred to a sanitary landfill.

In July 19, 1984 NRC completed review and concluded that our proposed transfer of the contaminated sludge by a contracted vendor to a public owned treatment works is acceptable. However, pursuant to 10 CFR Part 150, the NRC has delegated the authority to regulate by-product material in the State of South Carolina to the State's Bureau of Radiological Health.

Thus, permission for burial of by-product material in the State of South Carolina in a landfill must be issued by that agency. In addition, other state and local regulatory agencies may have some jurisdiction in this area. Therefore, the approval of this proposal is conditioned upon the licensee first obtaining approval by the relevant state and local agencies.

The NRC has reviewed the potential pathways for exposure to members of the general public from the radionuclides in the disposed sludge. These pathways include: (1) external exposure from standing on the ground above the disposal site, (2) ingestion of food grown on the disposal site, and (3) inhalation of resuspended radionuclides. The dose to a member of the public resulting from exposure to radionuclides via these pathways is estimated to be minimal due to the low concentrations of radionuclides in the sludge.

The estimated doses are a very small fraction of one year's exposure to natural background radiation (about 100 millirems or 1 milli Sv for the State of South Carolina).

Based on review of the proposed sludge disposal, the NRC concludes that the doses to members of the public as a result of exposure to radiation from the disposed sludge will be well below regulatory limits, and very small in comparison to doses members of the public receive each year from exposure to natural background radiation. Table II summarizes the estimated radiation doses from standing above the uncovered dried sludge bottoms and from ingestion of food.

Table II

Estimated external and internal dose to an individual

Nuclide	Average Concentration, pCi/gm (1 pCi = 37 mBq)	External Annual Dose mrem (1 rem = .01 Sv)	Internal Annual Dose, mrem	
			Total Body	Highest Dose to Any Organ
Co-58	0.092	0.06	0.0008	0.008 (GI-LLI)
Co-60	0.17	0.3	0.004	0.04 (GI-LLI)
Cs-134	0.083	0.1	0.06	0.07 (liver)
Cs-137	0.28	0.1	0.12	0.18 (liver)
Total		0.6	0.2	< 0.3

Case 4

By letter dated September 18, 1984 and Supplement dated November 28, 1984, Duke Power Company requested NRC approval pursuant to 10 CFR 20.302 of a proposed procedure to dispose of parts from five feedwater heaters in trenches on a proposed site within the company controlled area at Oconee Nuclear Station. The feedwater heaters are from the secondary systems of Oconee Units 1 and 2. The physical dimension of the feedwater heater is approximately 35 feet long and 5 feet in diameter. The principal radionuclides detected on the more highly contaminated surfaces of the heaters and their concentrations (pCi/gm) at the time of sampling are as follows: Mn-54 0.35; Co-60 10.1; Cs-134 0.52; and Cs-137 1.9. The total volume of the feedwater heaters is estimated to be about 10,500 ft^3 before cutting and segregation, and about 4,500 ft^3 after cutting. The total weight of the heaters is about 260 tons of which 160 tons would be disposed in trenches, and about 100 tons would be stored and eventually recycled. The total activity of the five heaters is conservatively estimated to be about 6.5 mCi (240.5 megaBq) with Co-60 and Cs-137 accounting for the largest fractions (i.e., 0.79 and 0.15, respectively) of the total activity.

The proposed disposed procedures are as follows:

(a) Cutting and Segregation

- The feedwater heaters will be cut into manageable lengths (approximately 8 feet long sections), the shells and tubes will be separated and placed in metal or wooden box containers.
- After cutting, heater sections will be segregated at the storage location with clean sections, per IE Circular No. 81-07 Guidance: Control of Radioactivity Contaminated Material [4], being disposed of through normal material section procedures and contaminated sections being transported to the proposed disposal site for burial.

(b) Disposal Procedure

- The contaminated sections (shells and tubes) will be placed into a 7 to 12 feet deep trench at the proposed burial site and covered with approximately 3 feet of uncontaminated soil.

- The clean sections or uncontaminated material (per IE Circular No. 81-07 Guidance: Control of Radioactivity Contaminated Material) will be disposed of via normal methods for noncontaminated scrap or as determined by Mechanical Maintenance.

(c) Administration Procedure

- Scrapping samples from the feedwater heater tube where the highest fixed contamination is suspected will be taken for radiological analysis and the results will be documented.
- The total waste volume and radioactivity inventories will be documented, and the total accumulated dose will be periodically evaluated.

In March 22, 1985, the NRC approved the storage and eventual recycling of the shells from the heaters contaminated at levels below reference values in IE circular NO. 81-07. Under 10 CFR 150, the NRC has delegated the authority to regulate by-product material to the state of South Carolina. Thus, permission for burial of by-product material must be issued by the state and local regulatory agencies.

The NRC has reviewed the potential pathways for exposure to members of the general public from the radionuclides in the disposed parts of the heaters. These potential pathways include: (1) external exposure from standing on the ground above the disposal site; (2) internal exposure from ingestion of food grown on the disposal site; (3) internal exposure from inhalation of resuspended radionuclides; and (4) internal exposure from drinking water. The dose to a member of the public from the most likely exposure pathway (i.e., external exposure) is conservatively estimated to be 0.01 mrem/yr (.1 μSv/yr) to the total body (See Table III). Doses to a member of the public from ingesting food grown on the disposal site and from inhalation of resuspended radionuclides are estimated to be minimal due to the proposed soil covering.

Doses from drinking contaminated water are estimated to be minimal due to the relatively low-level concentrations of radionuclides in the heaters, and the expected retention of radionuclides in the soil if the radionuclides migrated from the heaters. The estimated doses are a small fraction of one year's exposure to natural background radiation (about 100 millirems or 1 milli Sv for the State of South Carolina).

The potential doses to individuals and the population from exposure to 100 tons of recycled metal containing 10 pCi/g of Co-60. The maximum dose to an individual and the population from six recycling pathways investigated was estimated to be 14 mrems and 1.1 person-rems, respectively, during the first 30 years after recovery and recycling of the metal. The highest annual dose is estimated to be about 3 mrems to an individual and 0.15 person-rems to the population. The average concentrations of radionuclides in the segregated shells of the heaters should be much less than 10 pCi/gm since only surface contamination is of concern and the heaters shells will be cleaned prior to recycling. The highest annual dose is estimated to be much less than 2 mrems to an individual and 0.15 person-rem to the population from the proposed recycling of the cleaned heater shells.

TABLE III

Estimated Doses to An Individual Standing Above the Feedwater Heaters

Nuclide	Average Concentration, pCi/gm (1 pCi = 37 mBq)	Dose Rate, mrem/hr (1 mrem = .01 mSv)		Annual Dose, mrem
		Uncovered	Covered	
Mn-54	0.35	3.1.E-04	5.3 E-08	0.001
Co-60	10.1	2.7 E-02	4.6 E-06	0.009
Cs-134	0.52	8.8 E-04	1.5 E-07	0.001
Cs-137	1.86	1.1 E-03	1.9 E-07	0.001
Total		2.9 E-02	4.9 E-06	0.01

SUMMARY AND CONCLUSION

Duke Power Company estimates that the very low level radioactive wastes discussed above (a total of approximately 20,000 ft^3), if packaged and disposed of as radioactive waste, would cost approximately 1.5 million dollars. The use of actual burial space would be more than 23,000 cubic feet in the licensed radioactive waste burial site. The alternative disposal of these wastes also reduces risks during transportation associated with off-site shipments, whereas transport for the proposed action is for short distances entirely within company controlled access areas.

In summary, users of radioactive materials should not exclude the de minimis approach in their quest to reduce the volume of radioactive waste. There is, however, no specific regulatory provision for an unilateral disposal under the de minimis concept. The situation can best be described now as being on a case-by-case basis. NRC staff believes that it will be much easier to set forth generic limits for all waste after processing a few applications for particular waste streams. There is information available in the literature which can be helpful for comparison purposes in evaluation a specific situation[5]. In an assessment of the case yields what may reasonable be concluded to be de minimis, then a request for disposal under the provisions of 10 CFR 20.302 may well be in order.

REFERENCES

1. Code of Federal Regulations, Title 10, Chapter 1, "Standards for Protection Against Radiation."

2. Code of Federal Regulations, Title 10, Chapter 1, Part 61, "Final Rule Making-Licensing Requirements for Land Disposal of Radioactive Waste," December 27 1982.

3. U.S. Nuclear Regulatory Commission, IE Information Notice No. 83-05: "Obtaining Approval for Disposing of Very-Low-Level Radioactive Waste-10 CFR Section 20.302." February 24, 1983.

4. U.S. Nuclear Regulatory Commission, IE Circular No. 81-07: "Control of Radioactivity Contaminated Material," May 14, 1981.

5. U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards. "De Minimis Waste Impacts Analysis Methodology", NUREG/CR-3585, February 1984.