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A necessity for research in the recycling of concrete waste from the decommissioning

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1. Introduction

Construction of the I/LLW disposal site is now underway in Gyeongju. When completed it will be able to store 100,000 radioactive waste drums in a geologically deep disposal site; hence, a method for disposing of another 700,000 drums will be discussed.

Kori-1 is continuously being safely operated even after passing its 30 years designated life span. However, because 12 more nuclear power plants will operate past their designated life span by 2030, the necessity for research about their decommissioning will increase. Approximately 6,200 tons of radioactive waste will be generated from each decommissioned plant [1]. It will be difficult to store all of the waste in Gyeongju due to cost and efficiency issues.

For these reasons it is needed to discuss recycling methods for minimizing radioactive waste during decommissioning. This study suggests a scenario for recycling concrete waste of a decommissioned disposal site as crushed rock and also presents prior research for concrete waste recycling [2].

2. Methods and Results

2.1 Estimation of the recycling guidelines and the nuclide inventory

There is currently no regulation concerning radioactive waste recycling, nor is there any regulation for unconditional release that can be applied within the country. 100 Bq/g is applied as a standard of concentration for some nuclides such as ^3H, ^{14}C, etc., and 10 μSv/yr for other nuclides not mentioned in any regulation [3]. Because backfilling a disposal site with concrete waste is considered to be unconditional release, 10 μSv/yr is used as a dose assessment.

It would seem clear that the closest bioshield to a reactor would show the highest nuclide inventory out of the concrete waste generated from a nuclear plant. If it is possible to recycle this part, other concrete waste could also be recycled and the method applied to a broader range of materials to be disposed of.

This research also calculates the nuclide inventory of the bioshield of a Korea Standard Nuclear Power Plant (KSNP), the type of which comprises 40% of nuclear power plants, to broaden the range of application to other nuclear plants.

Derived Concentration Guideline Levels (DCGLs) would be evaluated for dose consequences (10 μSv/yr) using realistic release assumption by dose assessment code such as RESRAD-offsite. Specific data of only one disposal site, Gyeongju, are applied as disposal-site related data, especially. If the nuclide shown in the regulation has a DCGL over 100 Bq/g, 100 Bq/g would be applied as the guideline; otherwise, calculated DCGLs would be applied. Waste to be recycled should satisfy the following inequality:

$$\sum \frac{Concentration_i}{Guideline_i} < 1 \qquad (1)$$

Here, $Concentration_i$ means the *i*th nuclide's concentration of the waste which cannot be known before a plant is actually decommissioned. For this, the nuclide inventory is computed through a code such as MCNP-ORIGEN. The bioshield of KSNP is modeled through a formula such as MCNP, and the inner neutron flux is evaluated at every 0.2m intervals. The nuclide inventory is estimated using the ORIGEN library and applied to eq.(1). The amount of recyclable waste could be drawn out from the thickness satisfying the guideline.

2.2 Estimating the amount of radioactivity in a disposal-site recycling scenario

It could be impossible for the computed value of Section 2.1 to be wholly recycled depending on the amount of waste which could be unconditionally released as well as the scenario. If it is recycled as part of the backfill of the disposal site, radioactive waste would be disposed of with concrete waste. Therefore, considering radioactive waste as well, the amount of recycling waste should meet the effective dose guidance of the disposal site 0.1 mSv/yr.

Dose assessment is performed as per the method displayed in Section 2.1. Especially, if a computer code having a limited source term substitution is used such as the RESRAD-offsite, source terms of the waste must be adjusting by a weighting factor in the same ratio as the amount to be calculated and together they are considered as a single source term.

For a conservative evaluation, the source terms of the waste and recycling waste are evaluated by applying the largest inventory satisfying a disposal concentration limit [4] and the guideline respectively. Especially, evaluating the amount per silo would be easily applied in future cases, so data per silo is used. Through this, the amount of recycling waste is calculated with 0.1 mSv/yr to decide the ratio of crushed rock and recycling waste.

2.3 Effective dose during decommissioning

The nuclide inventory of the bioshield determines accordance with the guideline through a survey of several nuclear power plants. However, because we have an incomplete survey standard for decommissioning waste in Korea, the following formula suggested by the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) as provided by the U.S. NRC is used [5].

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2} \quad (2)$$

The P_r value used in this formula is dependent on the guideline. Values resulting from Section 2.1 and 2.2 were substituted for the guideline and survey sample respectively to determine the number of samplings. It could be calculated using a computer code such as COMPASS instead of Eq.(2).

The determined number of samplings, sampling time, and time taken to survey are applied in turn to evaluate the worker's exposure dose. A computer code such as the RESRAD-build simulates the bioshield decommissioning environment to sequentially perform an evaluation for removing the source terms. Also, a guideline could be devised to meet the worker exposure dose of 20 mSv/yr [6]. Finally, it appears that the guideline for recycling decommissioned concrete waste could be provided by comparing it with the guideline calculated in Section 2.1.

3. Conclusions

Generally, concrete waste generated during decommissioning has a low level of radioactivity, and it is expected that the cost for disposal would be considerably high if the amount of decommissioned concrete waste is large. Concerning this issue, it is needed to discuss methods for concrete waste recycling. Therefore, this paper suggests a method for using concrete waste as a part of the backfill for disposal site reclamation.

For this, recycling guidelines and the amount of waste which can be unconditionally released are evaluated, and the amount of actually recyclable waste is calculated according to the recycling scenario. Only on condition that the amount of concrete waste meets a target amount for radiation at the disposal site could it be replaced with crushed rock to be recycled. Also, the guideline should be set to be under the exposure dose workers are subject to while decommissioning. It is because the exposure dose workers or operators are subject to could be over a standard value in case only one guideline is applied for evaluation.

According to EUR-18041, the scenario for backfilling a disposal site with concrete waste would cost more than other recycling scenarios. However, it is indicated that efficiency would be maximized through the suggested sequential processes and thereby possibility of recycling will increase.

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