A Methodology of Selecting Potential Radionuclides for the Kori Unit 1 DCGL Calculation

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1. Introduction

A potential list of radionuclides is needed to ensure that the survey and characterization techniques based on the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [1] are appropriate and that doses have been assessed taking into account the radionuclides that may be present at the site. Nuclear facility operators should also ensure that the list of radionuclides developed through Historical Site Assessment (HSA) and operation history is applicable and appropriate for each contaminated materials. Therefore, a list of radionuclides should be developed for each type of material, reflecting site characteristics that are expected to remain after site remediation. The purpose of this study is to propose a methodology to make a list of potential radionuclides that will remain on the site after completion of the decommissioning of Kori Unit 1.

2. Methods

2.1 Rancho Seco Nuclear Power Station (RSNPS) case

RSNPS reviewed several NRC guidance documents in a way that theoretically defines the radionuclides that are potentially present at the decommissioning site. This includes NUREG/CR-3474, NUREG/CR-4289, and NUREG/CR-0130.

However, the potential radionuclides based on the reference document were directly not appropriate, so additional technical reviews were carried out. Several radionuclides were added using ORIGEN computer code, and the incident history illustrated in the historical site assessment was also included. Finally, detected radionuclides in the spent fuel system were added.

The list of potential radionuclides based on the above criteria includes minor radionuclides and their importance was evaluated by qualitative comparison of the total radioactivity. For the discounted radionuclides from the regulatory references and the ORIGEN code, the radionuclides of less than 0.1% of the radioactivity concentration were considered to be excluded, and the dose was confirmed to be insignificant by using DandD code. Among the discounted radionuclides, there are some not supported by the DandD code. In this case, it is confirmed that the weighted Dose Conversion Factor (DCF) is insignificant compared with those of Co-60 and Ni-63 which have high radioactivity ratio. In addition, naturally occurring radionuclides and noble gases are discounted because they are less likely to be found at the site. Table shows the list of potential radionuclides for the RSNPS.

Table 1. Potential radionuclide list of RSNPS

H-3	C-14	Na-22	Fe-55
Ni-59	Co-60	Ni-63	Sr-90
Nb-94	Tc-99	Ag-108m	Sb-125
Cs-134	Cs-137	Pm-147	Eu-152
Eu-154	Eu-155	Np-237	Pu-238
Pu-239	Pu-240	Pu-241	Am-241
Pu-242	Cm244		

2.2 Zion Station case

The Zion Nuclear Station also starts with a list of potential radionuclides from a theoretical list with reference to regulatory documents similar to RSNPS. They reviewed guidance document including NUREG/CR-3474, NUREG/CR-4289, and WINCO-1191. WINCO-1191 presents a theoretical list of radionuclides expected to come from PWR and BWR, and includes both fission and activation products.

In a slightly different way than the RSNPS, Zion Station analyzed and reviewed the representative radioactive waste samples collected at the site to supplement the list of potential radionuclides. A total of 19 samples analyzed were reviewed, which are based on the waste characteristics data collected after the permanent shutdown of nuclear facilities.

To eliminate minor radionuclides, Zion Station selected discounted activation products from NUREG/CR-3474 where the radioactivity fraction for Co-60 and Ni-63 was less than 0.01%. It was also excluded for noble gases that were not expected to be measured at the site. Table shows the list of potential radionuclides for the Zion Station.

Table 2. Potential list of potential radionuclides

H-3	C-14	Fe-55	Ni-59
Co-60	Ni-63	Sr-90	Nb-94
Tc-99	Sb-125	Cs-134	Cs-137
Pm-147	Eu-152	Eu-154	Np-237
Pu-238	Pu-239	Pu-240	Pu-241
Am-241	Am-243	Cm-243	Cm-244

3. Results & discussion

We reviewed a methodology for developing the initial list of potential radionuclides from the RSNPS and Zion Station. As a result, it can be seen that they first made a starting point from the data in the regulatory documents, and added supplemental data such as historical site assessment, sampling analyzed, and ORIGEN code, etc. Based on these cases, a methodology for the list of potential radionuclides of Kori Unit 1 decommissioning can be developed.

3.1 Resources for selecting potential radionuclides

First, referring to the overseas cases, the starting point is the result of the review of the radionuclides in the reference documents: NUREG/CR-3474, NUREG/CR-4289, and NUREG/CR-0130.

Next, reference to the radionuclides considered for radioactive waste for the nuclear power plants currently in operation will be possible. Therefore, it may include 14 radionuclides specified in the Nuclear Security and Safety Commission (NSSC) Notice No. 2017-60, “Regulations for the Management of Low and Intermediate Level Radioactive Waste”.

Others, as a reference to consider, may be possible by executing the ORIGEN code for the radionuclides produced in the nuclear fuel assembly that has undergone 15 years of radioactive decay after the permanent shutdown. It should also reflect the HSA data and the radionuclides detected in the future at the site.

3.2 Discounted radionuclides

For the discount methodology, first, the radionuclides specified by NUREG/CR-3474 are considered for selection of discounted radionuclide if the radioactivity fraction decayed for 15 years is less than 0.1%. In the case radionuclides selected from the ORIGEN code, in the same way, if the fraction of radioactivity is less than 0.1% of total inventory, it also can be considered for discount.

3.3 Dose evaluation for discounted radionuclides

In order to eliminate radionuclides with a radioactivity of less than 0.1% of total from those of discounted, the dose fraction of the discounted radionuclides should be less than 1% of the total dose. In case of overseas cases, the evaluation was made for radionuclides that can be supported by the DandD code. Otherwise, the weighted DCF was compared. The DandD code can be used for Kori Unit 1, but it is also possible to use the RESRAD code because many decommissioning plants adopted RESRAD code to calculate residual activity of potential radionuclides. Therefore, it is appropriate to use RESRAD code to show the dose of discounted radionuclides is insignificant. The overall procedure can be depicted as shown in Fig. .

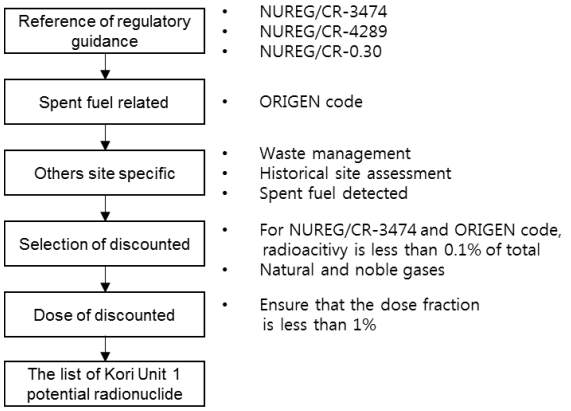

Fig. 1. Process of potential radionuclides selection.

4. Conclusion

In this paper, we reviewed the RSNPS and Zion Station cases of developing the list of potential radionuclide, and propose a methodology for Kori Unit 1 decommissioning. To summarize, starting from the regulatory guidance, the initial list is made together with referring to site history, sampling, and radioactive waste stream, and radionuclides not important are eliminated by comparing the fraction of radioactivity. And dose assessment can be performed on the discounted radionuclides to confirm that their effects are insignificant. Therefore, it is possible to select the potential radionuclides of Kori Unit 1 through this methodology.

REFERENCES

[1] NRC, Multi-Agency Radiation Survey and Site Investigation Manual, U.S. Nuclear Regulatory Commission, 2000.