A Case Study of Remediation Actions and Cost-Benefit Analysis Considered During the Site Remediation Phase

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1. Introduction

In order to reuse the site after the decommissioning of Nuclear Power Plant (NPP), at the license termination phase it needs to reduce the amount of the residual radioactivity concentration to a certain level for media such as soil, remaining buildings, etc. within the site. These efforts can be called as activities related to the remediation actions, and are generally performed at the last phase of decommissioning. The residual contamination above the acceptable level of the final site state shall be removed, and the final site state determines whether the site is cleared or not. Furthermore, along with the compliance with the regulatory rules, the site may need to meet the ALARA in order to conform to the optimization principles as well as the DCGL criteria [1]. Therefore, this study aims to review the remediation actions considered in the previous decommissioning NPPs and the costs and benefits they applied.

2. Methods and Results

In this study, in order to review the experience cases of remediation actions with ALARA action levels and to derive insights applicable to domestic decommissioning projects, the evaluation methodology and experiences of the Rancho Seco site in the U.S. were referred.

2.1 General Remediation Technologies by Media

During the operation of NPPs, Systems, Structures, and Components (SSCs) can be contaminated from radioactive substances or materials. In addition, radioactive contamination can also occur in the buildings where these SSCs are installed, managed and in the buildings set up as radiation controlled areas. Typically, representative decontamination technologies that can be used for the surface of these structures include washing, wiping, pressure washing, vacuuming, scabbling, chipping, sponge or abrasive blasting. Therefore, technologies that can be applied to decontamination activities in the site remediation phase in NPP decommissioning can be largely divided into structural and soil-targeted activities.

Table I: Remediation Action [2]

Technology		Summary
Structures	Scabbling & Shaving	To remove contamination from concrete surfaces, and tungsten carbide tips are attached to pneumatic air pistons to crush concrete surfaces. Shaving uses a diamond cutting wheel to the spindle, and it can work at a speed similar to that of scabbling
	Needle gun	A second form of scabbling is accomplished using needle guns. The needle gun is a pneumatic air-operated tool containing a series of tungsten carbide or hardened steel rods enclosed in a housing.
	Chipping	Chipping includes the use of pneumatically operated chisels and similar tools coupled to vacuum-assisted collection devices.
	Sponge & Abrasive Blasting	Sponge and abrasive blasting are similar techniques that use media or materials coated with abrasive compounds such as silica sands, garnet, aluminum oxide, and walnut hulls
	Pressure Washing	Pressure washing uses a hydrolazer-type nozzle of intermediate water pressure to direct a jet of pressurized water that removes surficial materials from the suspect surface
	Washing & Wiping	Washing and wiping techniques are actions that are normally performed during the course of remediation activities and will not always be evaluated as a separate action
	Grit blasting	Any remaining contaminated piping buried or embedded in concrete may be remediated using methods such as grit blasting
Activated Concrete		Removal of concrete may be accomplished using a machine mounted, remote-operated articulating arm with exchangeable actuated hammer and bucket (sawing, impact hammering and expansion fracturing may also be employed)
Soil Excavation		Soil remediation equipment will include, but not be limited to, back and track hoe excavators.

2.2 Rancho Seco ALARA Action Level Evaluation

Dose assessment models require characteristic factors such as size of contaminated areas and contamination density to calculate costs and benefits for averted doses. The application scenario for soil and remaining buildings was the industrial worker scenario. The ALARA evaluation method of the Rancho Seco utilized the methodology offered in Appendix N of NUREG-1757 [3]. Through ALARA evaluation, the benefit and cost of the profit from avoidance doses and the cost of remediation activities were evaluated.

2.3 Rancho Seco Remediation Methods

Remediation actions in Rancho Seco include scabbling, wiping, pressure washing, grit blasting, sponge & abrasive blasting and soil excavation. Table II below shows the characteristics of these methods.

Table II: Rancho Seco Remediation Actions [2]

Action	Method
Scabbling	▪ 0.125 inches depth of concrete surface ▪ 115 ft^2/hr ▪ Remove 100% of contamination
Pressure washing	▪ 20,312 m^2 treatment of structural surface ▪ 22.3 m^2/hr, waste generation 5.4 L/m^2 ▪ Remove 25%
Wet & Dry Wiping	▪ 20,312 m^2 treatment of structural surface ▪ 2.8 m^2/hr ▪ Remove 100% glassiness and reduce general contamination by 20%
Grit blasting	▪ Decontaminate 5,354 linear feet ▪ Remove 95% contamination
Sponge & Abrasive blasting	▪ 2.8 m^2/hr decontamination rate ▪ Film and paint is effective
Soil excavation	▪ 1,500 m^3 soil excavation ▪ 95% reduction

2.4 ALARA Evaluation Result

Rancho Seco conducted an ALARA evaluation on the scenario of industrial workers. In this case, consideration was made for multiple radionuclides. 26 radionuclides were identified above Minimum Detectable Concentration (MDC) in soil while 21 have been identified at least one time in structural samples. For purpose of the ALARA evaluations, only Co-60 and Cs-137 were used along with their associated DCGLs. Table Ⅲ shows the results derived from the ALARA action level evaluation in Rancho Seco.

Table Ⅲ: Rancho Seco Results (Conc/DCGL) [2]

Action	Unit Costs ($)	Conc/DCGL
Pressure washing & Vacuuming	15.31	1.31
Wiping/Washing	58.87	6.31
Concrete scabbling (upper bound)	67.02	5.75
Concrete scabbling (lower bound)	33.36	5.72
Grit blasting surfaces (upper bound)	96.88	2.19
Grit blasting surfaces (lower bound)	80.58	1.82
Grit blasting Embedded/Buried piping	27.49	42.77
Soil Excavation	2,679.82	1142.00

2.5 Discussions

In evaluating ALARA action levels, this study reviewed the Rancho Seco case, but confirmed that Maine Yankee, Yankee Rowe, and Connecticut Yankee NPPs applied similar methodologies. In terms of domestic application measures, we can first select remediation activities for release media by referring to overseas cases. It is necessary to determine the cost factors based on the activities, and the benefits of averted dose should also be evaluated. In addition, parameter values such as remediation area, interest rate, population density, decontamination factor, etc. for applying the Conc/DCGL relationship should be determined reflecting the circumstance of the NPP.

3. Conclusions

Through the literature, it was possible to confirm information on the cost items they used and the unit prices considered when calculating the value of each remediation actions. In addition, it was found that there are multiple radionuclides rather than single in the actual field, and the associated DCGL values (adjusted DCGL for Co-60 and surrogate DCGL for Cs-137) considered in the cost-benefit formula were necessary. Considering overseas remediation actions, this study is expected to be used as a reference in terms of identifying factors that can be considered in the future for NPPs in domestic decommissioning projects.

REFERENCES

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