Experience Case of ALARA Evaluation Considered During Site Remediation Phase

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1. Introduction

In order to reuse the site after the decommissioning, it is necessary to reduce the amount of radioactivity concentration to a certain level for media such as soil and groundwater around the site. These activities are called the remediation actions, and are generally performed at the last phase of decommissioning. In the site remediation phase, 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, at the time of license termination phase, the site may need to meet the ALARA principles 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 order to review the experience cases of remediation actions and ALARA evaluation and to derive implications applicable to domestic decommissioning projects, the evaluation contents and experiences of the Maine Yankee NPP in the U.S. were referred.

2.1 General Remediation Technologies by Media

During the operation of NPPs, Systems, Structures, and Components (SSCs) are continuously contaminated from radiation or radioactive materials. Contamination will also occur in the containment buildings where these SSCs are installed or managed and in the buildings set up as radiation management areas. Representative remediation 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 restoration stage in NPP decommissioning can be largely divided into structural and soil-targeted technologies.

Table I: Remediation Action [2]

Technology	Summary
Scabbling	To remove contamination from concrete surfaces, and tungsten carbide tips are attached to pneumatic air pistons to crush concrete surfaces
Shaving	The surface is cut while rotating by attaching a diamond cutting wheel to the spindle, and it can work at a speed similar to that of scabbling
Needle gun	As a type of scabbling method, this is a method of cutting the surface to be worked using a tungsten rod. 1~2mm is removed in one operation
Chipping	This work is usually applied to cracks and crevices, but it can also be used to remove pedestal foundations or similar equipment platforms
Sponge	Uses a foam-type medium that absorbs contaminations during impact and compression, and it is a less destructive than the scabbling method
Washing	To remove contaminants from the media surface by spraying water jets on the surface using a Hydrolyzer-type nozzle that sprays a water stream of medium-level water pressure
Wiping	It may be applied when decontamination equipment such as decontamination of stairs and railings, decontamination of structural materials and metals, and washing is not available
Water blasting	This method utilizes a high-pressure liquid injection system, and a rotary tip that can cover all the inner surfaces of the pipe is used
Grit blasting	To decontaminate the interior of contaminated piping. In particular, the remaining pipes buried or buried in concrete can be restored in the same way as grit blasting
Soil excavation	Physically removing contaminated soil exceeding DCGL and treating it with radioactive waste

2.2 MY 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 residential farmer and industrial worker scenario. The ALARA evaluation method of the MY 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.

If the benefit from the avoidance dose is greater than the cost invested in the remediation activity, additional remediation activities are required. On the other hand, if the cost is less than the profit, additional remediation activities are not required. The cost of remediation activities may vary due to several factors.

- Costs due to the remediation action
- Cost of waste transportation and disposal incurred
- Worker's accident costs during work
- Cost of traffic fatalities while transporting waste
- Dose costs for workers transporting waste to treatment facilities
- Dose costs for the general public when excavating, transporting and disposing of wastes
- Cost for a particular situation

2.3 MY Remediation Methods

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

Table II: MY Remediation Actions [2]

Action	Method
Scabbling	▪ 0.25-0.5 inch depth of concrete surface ▪ 1.86 m^2/hr ▪ Remove 95% of contamination
Pressure washing	▪ 100% treatment of structural surface ▪ 9.3 m^3/hr, waste generation 5.4 L/m^2 ▪ Remove 25%
Wiping	▪ Wet and dry applicable ▪ 2.8 m^2/hr ▪ Remove 100% glassiness and reduce general contamination by 20%
Grit blasting	▪ Decontaminate inside piping, 1,877 m long ▪ Remove 95% contamination
Sponge & Abrasive blasting	▪ 2.79 m^2/hr decontamination rate ▪ Film and paint is effective
Soil excavation	▪ 1,450 m^3 soil excavation ▪ 95% reduction, 4 workers

2.4 ALARA Evaluation Result

MY conducted an ALARA evaluation on the scenario of resident farmers and industrial workers. In this case, consideration was made for multiple radionuclides, and H-3, Fe-55, Co-57, Co-60, Ni-63, Sr-90, Cs-134, and Cs-137 were mainly considered for building and structure remediation actions. In addition, H-3, Co-60, Ni-63, and Cs-137 radionuclides were considered for soil excavation. Table III shows the results derived from the ALARA action level evaluation in MY.

Table III: MY Remediation Actions (Conc/DCGL) [2]

Action	Residential Farmer	Building Reuse
Pressure washing	99.4	1.9
Wiping/washing	312.6	6.0
Concrete scabbling (upper bound)	143.9	2.76
Concrete scabbling (lower bound)	123.9	2.38
Grit blasting surfaces (upper bound)	153.3	2.94
Grit blasting surfaces (lower bound)	118.9	2.8
Grit blasting embedded/buried pipe	91.6	-
Soil excavation	733.9	-

3. Conclusions

Remediation of the site, the final stage in the decommissioning of nuclear facilities, is a task to be carried out in terms of reuse of the site. In this point, in addition to the dose criteria which is a legal standard, decontamination activities on the ALARA were considered in overseas cases. 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 item. In addition, it was found that there are multiple radionuclides rather than single in the actual field, and the fraction of radionuclides to be 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

[1] NSSC, "Criteria for Reuse of Site and Builings after Completion of Decommissioning of Nuclear Facilities," Notice No. 2021-15, Nuclear Safety and Security Commission, 2021.

[2] MYAPC, "Maine Yankee's License Termination Plan," Rev. 5, Maine Yankee Atomic Power Company, 2009.

[3] NRC, "Consolidated Decommissioning Guidance," NUREG-1757, Vol. 2, Rev. 1, U.S. Nuclear Regulatory Commission, 2006.