Review on the Liquid Radioactive Material Leakage Accidents in the U.S.

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1. Introduction

Korean nuclear power plants (NPPs) are expected to enter the phase of permanent shutdown in the 2020s if there is no extension of their design life. Kori unit 1 is in the process of preliminary work to prepare for decommissioning after the decision of permanent shutdown in June 2017, and the on-site restoration work is scheduled in 2031. Korea has no experience of decontamination of groundwater and soil pollution in NPP site, therefore, it is useful to review previous experiences of other countries for establishing strategies for restoration of groundwater and it is important to develop effective remediation strategies based on the analysis of groundwater and soil pollution decontamination cases from operating NPPs in the U.S. The purpose of this study is to investigate the contamination case from operating NPPs in the U.S. and to propose some valuable considerations.

2. Case Study on Liquid Leakage Accidents

A total of 14 operating NPPs that experienced contamination with leaked lipid radioactive materials were investigated as shown Table 1.

Table 1. NPPs where liquid radioactive materials were leaked during operation

NPP	Type	Op./Shut.	Capacity (MWt)
Oyster Creek	BWR	1969/2018	1,930
Brunswick Unit 1	BWR	1977/undecided	938
Brunswick Unit 2	BWR	1975/undecided	920
Quad Cities Unit 1	BWR	1973/2018	908
Quad Cities Unit 2	BWR	1973/2018	911
Callaway	PWR	1984/undecided	1215
Braidwood	PWR	1988/undecided	1194
Palo Verde Unit 2	PWR	1986/undecided	1314
Palo Verde Unit 3	PWR	1988/undecided	1312
Byron	PWR	1985/undecided	1164
Indian Point Unit 1	PWR	1962/1974	615
Indian Point Unit 2	PWR	1974/undecided	3216
Point Beach	PWR	1970/undecided	591
Three Mile Island	PWR	1974/undecided	2568
Watts Bar	PWR	1996/undecided	3459

Table 2 lists the causes of the liquid radioactive materials leakage accidents in operating NPP and the countermeasures.

Table 2. Summary of Leakage Accidents in NPPs

NPP	Leak Detection		Nuclide	Cause	Countermeasures
	Date	point			
Oyster Creek	2009. 04.15	Condensate Transfer System	H-3	Leakage from pipelines of 8 and 10 inch diameter between facility and Condensate Storage Tank	Pipeline Replacement
Brunswick	2007. 05.07	Manhole near Storm Drain Storage Pond	H-3	Leakage from Storm Drain Storage Pond	Continuous analysis of concentration after installing additional tube well for sampling
Quad Cities	2007. 10.12	Tube well newly installed in site	H-3	Suspected underground pipeline connected to Condensate Storage Tank	Inspection of underground pipeline connected to Condensate Storage Tank and installation of additional tube well for concentration monitoring

Callaway	2006. 06.14	Surface toil inside manhole where drainage valve is installed	H-3 Cs-134 Cs-137 Co-58 Co-60	Leakage through vacuum breaker valve during discharge of liquid radioactive materials through drainage pipeline	Suspension of discharge of drainage pipeline and installation of Collecting Pond below valve to capture leakages
Braidwood	2005. 03	Well near NPP	H-3	Leakage through openings of vacuum breaker valve in circular water drainage pipe and drainage cooler protection valve in Feed Water System	decontamination of H-3 after installation of additional tube well for identifying contaminated area
Palo Verde	2006. 03.01	Groundwater in Unit 3 area	H-3	Gas leakage from Boron Concentrating System	Installation of new tube well and continuous monitoring and evaluation
Byron	2006. 02.10	Storage room for vacuum breaker valve	H-3	Leakage from Vacuum Breaker Valve	Determination of contaminate area and leakage monitoring
Indian Point	1992	Spent Fuel Pool Water	H-3, Ni-63, Cs-137 Sr-90 Co-60	Welding defect in SFP Stainless Liner	Isolation of leakage area (Installation of Collecting Pond))
Point Beach	1975.02	Pond in site	H-3 Cs-137	Rupture of Steam Generator tube	Groundwater monitoring and submission of site-specific report on contamination
Three Mile Island	1999	Condensate Storage Tank	H-3	Rupture of ice-making pipeline	Continuous and enhanced monitoring of groundwater
Watts Bar	2004. 12.29	Shield Building annulus in Unit 2	H-3	Waste discharge pipeline and temporary radioactive waste pipeline	countermeasure to remove contaminate soil

Table 2 showed that the contamination-related nuclear species were Cs-137, Co-60 and H-3, and where H-3 was dominant. The causes of contamination were valve defects, operational accidents by operator and welding defects during repair work with leakage through valve rupture of pipeline being dominant. In the United States, countermeasures were replacement or repair of the pollutant valve and no specific decontamination activity on soil contamination was performed. In the case of groundwater, the management activities were continuous monitoring not to exceed 20,000 pCi/L which is a EPA criterion for drinking groundwater. In Korea, the fact that the groundwater in decommissioned NPP site is not used as drinking water should be considered in establishing evaluation and decontamination criteria, and the restoration methods should be selected based on the analysis of the contamination range of groundwater and soil in the NPP sites to be decommissioned.

3. Conclusion

This study reviewed groundwater and soil pollution cases of NPPs in the U.S. We proposed several considerations specific for conditions in Korea. It was found that the investigation of major contaminated area, currents status of a radionuclide H-3 distribution, and development of continuous monitoring plan and evaluation guide of groundwater are needed.

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