Experience Review of Full System Decontamination for Decommissioned NPPs

Jaeyong Lee, Kyungmin Kim, Seo-yeon Cho, Yong-soo Kim*
Department of Nuclear Engineering, Hanyang University,
222 Wangsimni-ro, Seongdong-gu, Seoul 133-791, Korea
**Corresponding author: yongskim@hanyang.ac.kr*

1. Introduction

All over the world, the decommissioning of nuclear power plant (NPP) has been growing steadily since Fukushima accident in 2011. The number of shutdown NPPs is totally 150 globally and decommissioned NPPs is 20 in the world [1].

But Korea has only experience of decommissioning of research reactor (TRIGA MARK-3). Based on the NPP lifetime as a 45 years, 16 NPPs in Korea will come to an end of their lifetime until 2060 and Kori-1 will be permanent shutdown in 2017.

Decommissioned NPPs were applied by various technology. Among them, Full System Decontamination (FSD) is chemical process to decontaminate primary system before decommissioning (transition period) and has important objectives.

- To remove of residual radioactive materials from primary system
- To minimize the radiation exposure for operation personal and the public
- To minimize the radioactive waste
- To reduce disposal cost

In this study, it was investigated that principle of various FSD technology and result of FSD for decommissioned NPPs in the world.

2. Full System Decontamination Activities

2.1. Full System Decontamination process

FSD chemically decontaminate the primary system using reactor coolant system without decomposing or cutting the system.

The main radioactivity is due to corrosion product in the water chamber and tubules of the primary system. Therefore, the evaluation of the FSD depends on the effective removal of the corrosion oxide film.

FSDs is largely classified according to multistep decontamination and single-step decontamination [2]. The feature of multistep decontamination has to dissolve oxide layer without damage of base metal. On the other hand, single-step decontamination dissolves base metal.

Due to production of secondary radioactive waste problem, multistep decontamination had been commonly used for NPP decommissioning in the world.

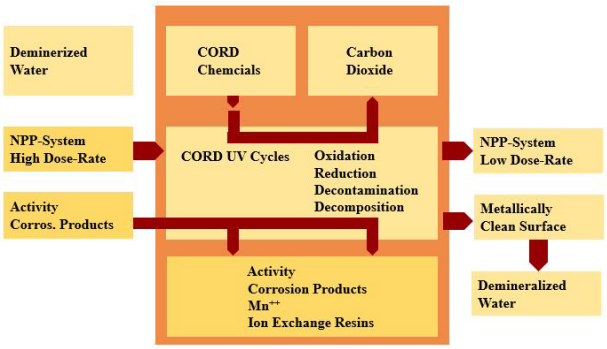


Fig. 1. Schematic diagram of HP/CORD UV

Among multistep decontamination, Fig. 1 show that CORD (Chemical Oxidizing Reducing Decontamination) process developed by Simens KWU (AREVA) is multi cycle of four step chemical process.

Another multistep decontamination is DFDX (Decontamination For Decommissioning electrochemical ion eXchange) process is developed by the EPRI. DFDX consists of chemical injection equipment included chemical mixed tank and injection pump, filter, ion exchange columns, process heater and cooler.

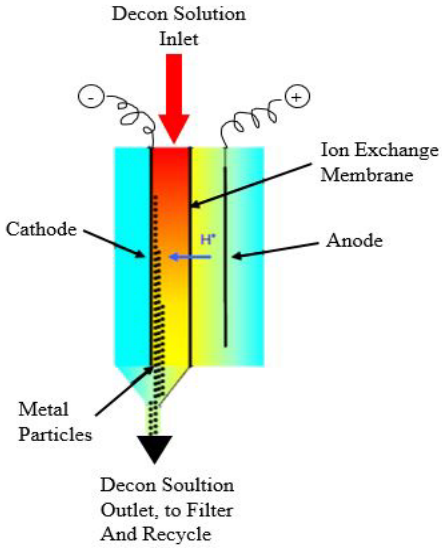


Fig. 2. Schematic diagram of DFDX

The Table. 1 show that reagents and steps of two multistep decontamination were chemically different. But, the process of the two decontamination commonly has oxidation of chromium oxide and removal byproduct [3].

Table. 1. Multistep decontamination method

	CORD	DFDX
Reagents And Parts	$HMnO_4$ $H_2C_2O_4$ Ion exchange resin UV light	HBF_4 $KMnO_4$ $H_2C_2O_4$ Ion exchange resin
Steps	Oxidation Reduction Decontamination Decomposition	Oxidation Reduction Transition

2.2. Experience of Decommissioned NPPs

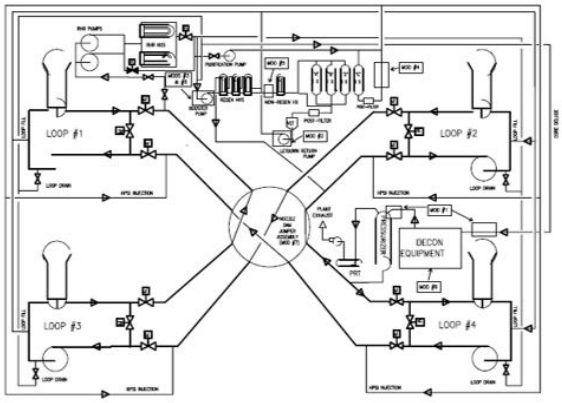
Now there are 20 decommissioned NPPs in the world. Among them, 3NPPs (Connecticut Yankee (CY), Maine Yankee (MY), Vak Kahl (VK)) was applied by FSD.

Because FSD was not necessarily applied for decommissioned NPPs due to a radiation survey of NPPs for low radiation levels that exist in the primary system. Table. 2 show the comparison of the reactor history and result of FSD using CORD or DFD.

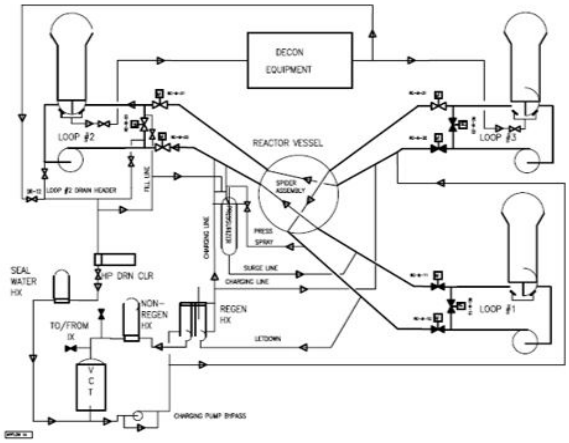
Table. 2. Comparison of FSD for decommissioned NPPs

Name	CY	MY	VK
Type	PWR	PWR	BWR
Capacity (MWe)	560	860	15
Operating Duration	28 yrs	25 yrs	23 yrs
D&D Duration	1998-2007	1997-2004	1988-2010
FSD Type	CORD	DFD	CORD
FSD Cycle	2	24	5
Metal Removed (Kg)	182	307	137
Decontamination Factor	17.6	8.7	-
Radioactivity Removed (Ci)	130	102	168
Scope of Decontamination	RCS (excluding RPV), A portion of SG	RCS loop, PZR, CVCS, RHRS, Letdown, Charging system	RPV, RCS loop, RHRS,
Surface Area SS, (m^2)	1997	465	30
Abnormal Accident	O	X	X

The result of comparison for FSD is difficult because of NPP type, capacity, scope of decontamination (Fig. 3) in system and abnormal accident.



(a)



(b)

Fig. 3. Diagram of (a) CY NPP using CORD (b) MY NPP using DFD (Application 1)

3. Conclusions

Review of the experience for FSD show that decommissioned NPPs were conducted considering the removal of radioactivity. Also, it is important to conduct planning and appropriate method considering NPP type, operation duration and postulated accident.

As shown in decommissioned NPPs using FSD, the amount of the secondary radioactive waste varies depending on the scope of applied system. In the Korea, the best strategy to consider the minimum secondary radioactive waste production and safety of worker and the public should be planned and implemented above all.

Acknowledgment

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