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Decontamination Planning and Approach to its Methodology

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1. Introduction

Decontamination is a process which should be considered during the decommissioning project to reduce the risk of radiation exposure. So, the research of the approach to the decontamination is required since Korea doesn't have the NPP decommissioning experience.

In this paper, the process flow of decontamination is described throughout the foreign case study. And, factors needed to be considered to progress decontamination smoothly are introduced.

2. Methods

The methodology planning for decontamination is introduced in this section which consists of 5 sub-sections .

The chemical method among many decontamination technologies is dealt in this paper since it is the best method when efficiency, feasibility, and economy are considered.

2.1 Organizations for decontamination

There are 5 key organizations which are related with the decontamination project in Korea. NSSC is a regulatory body. KINS is entrusted to supervise the nuclear facilities from NSSC. KHNP is owner of NPPs in Korea. Contractor is defined as the hands-on organization which perform the decontamination in field. Licenser is the organization that possess the related technologies of the know-how.

Firstly, general and detailed regulations are needed since various chemical materials used for it have direct and indirect risk factors. Then the obtaining of related technologies are required. From this step, the final level of radioactive waste can be projected. It also means that it is possible to assume the amount of radioactive waste and the cost for waste management.

And, the KINS and the contractor have to make procedures with KHNP. KHNP should offer the data and condition of NPP to assist developing decontamination procedures and review the procedures to determine feasibility and efficiency. Lastly, KHNP modify those for optimization of facilities.

The Figure 1 and Table 1 show the task flow of organizations.

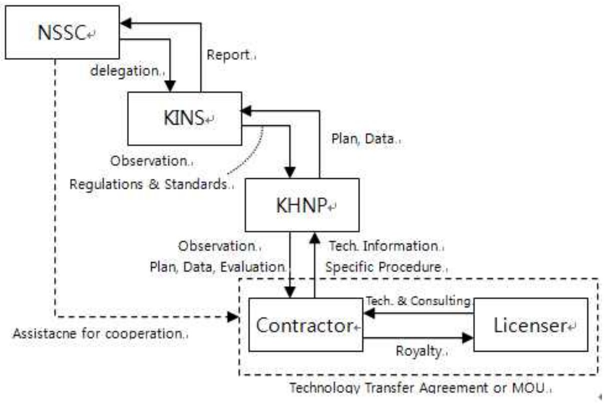

Fig. 1. Task flow of related organizations

Table 1. Roles of related organizations

Organization	Roles
NSSC	- Review related regulations and data - Assistance & surveillance of management
KINS	- Evaluation of technologies - Surveillance of decontamination process in field - Developing general & detailed safety regulations - Developing the NSSS interface procedures & evaluation procedures
KHNP	- Planning - Decision of a proper contractor - Preliminary evaluation of technologies - Inspection of equipments and related NSSS systems - Evaluation, Modification, and safety review of procedures - Surveillance of decontamination process in field
Contractor	- Performing decontamination - Preparation of equipment and related tools - Developing starting & operating procedures - Support KINS to develop the NSSS interface procedures & evaluation procedures
Licenser	- Consulting & Technology transfer(depending on agreement)

2.2Decontamination planning

The decontamination can be distinguished by dismantling point between before dismantling and after. This decision should be determined before the preparation step. Because, according to the time of application, the whole decommissioning process(including applied technology, radiation protection, waste management and etc) will be changed.

The objectives of decontamination of before dismantling are

- To reduce the risk of contamination spread during further dismantling of the component
- The reduction of the dose rate of people from radiation exposure

And, the objectives of decontamination of after dismantling are
- To change the waste category for disposal
- To reuse and recycle the material dismantled
- To reduce the dose rate during further waste handling

To perform decontamination in earnest, the first decision should be determined is whether large components are contained in contamination items or not. While the full system decontaminations of the operational NPPs was performed with large components, the many shut-down NPPs(such as Maine Yankee and Connecticut Yankee) recently didn't include those due to the efficiency and the economical profit.

The next step is selecting proper technology. Two decontamination technologies are introduced at section 2.3 (EPRI DFD and CORD D UV). The evaluation of performance between the two technologies is not important, since the DF is related with the number of cycles. Only need to repeat the decontamination cycles to get the desired value of radioactivity. For example, in case of Connecticut Yankee, three cycles of decontamination were planned. But just two cycles were enough to get the desired value due to the good efficiency of technology. The differences of the two technologies are the cost, the work time, the equipments and the generated amount of the liquid waste. So, when the decommissioning of NPP in Korea will be performed, one of proven technologies or new technology can be applied trough the assistance of the related organizations.

After the decision of technology, various decontamination procedures should be prepared. These were defined as follows:
- Task A : Development of the detailed start-up and operating procedures for the decontamination process system (DPS)
- Task B : Development of the interfacing procedures for the NSSS systems
- Task C : Completing the detailed engineering evaluations and calculations required for developing the NSSS interface procedures
- Task D : Development of guidelines, procedures, and completion of detailed design work in support of required NSSS equipment inspections and modifications
- Task E : Safety Review of the decontamination procedures

2.3Decontamination Technologies

In case of decontamination for decommissioning of NPP, DF(decontamination factor) should be high to reduce the radioactivity of waste down to the release level. While a DF of 10 is generally used for operating plants, a DF of 100 or more is suitable for a decommissioning project.

In this sub-section, some techniques of high DF are described and some factors influencing management are proposed.

Table 2 and 3 show examples of the decontamination technology which are suitable for permanent shut-down NPP.

DFD was developed by EPRI recently. It is the more aggressive process than operational-type such as LOMI, CAN-DREM and CITROX with >1,000 DF reported.

Table 2. Summary of DPRI DFD

title	EPRI DFD	
process	(i) Oxidation(2~4hours) (ii) Reduction(12hours) (iii) Transition(2~4hours)	Adding ~200ppm $KMnO_4$ Adding an excess of oxalic acid Returning to the base solvent
feature	Using Fluoroboric Acid(0.08%) as the base solvent Reagent dilute and chemical costs low Suitable for cleanup on IX(Ion Exchange) resin	
Experience	1) Big Rock Point : 70MWe BWR, 37yrs operation - decon' volume(area) : 32,000 gallons (10,764 ft^2) - period : 1st(9days for 6 cycles), 2st(3days for one cycle) - 410 curies of gamma nuclides removed (DF 27) 2) Maine Yankee : 825MWe PWR - Bypassing large components (SG, Reactor) - period : 1st(8days for 11cycles), 2st(8days for 13cycles) - liquid waste generated : 625 ft^3 - 103 curies of gamma nuclides removed (DF 31.5)	

Recently, the EPRI DFDX process that is more efficient and economic technology was developed from DFD. This technology includes processing of the radioactive solution using electrochemical ion exchange to produce a minimal metallic waste.

Siemens developed CORD for decontamination of operational facilities. According to the need of high DF, CORD D UV was developed from the CORD for permanent shut-down NPP.

Table 3. Summary of the CORD UV

title	CORD D UV	
process	(i) Oxidation (ii) Reduction (iii) Decontamination (iv) Decomposition	Adding 50~300ppm permanganic acid($HMnO_4$) Adding 550ppm oxalic acid Adding 1,500ppm oxalic acid Removal of oxalic acid(UV)
feature	No need to cleanup or drain system between steps Shorter time & Less waste	
Experience	1) Connecticut Yankee(Haddem Neck) : 619 MWe PWR - Bypassing large components (SG, Reactor) - Existing equipments in NPP were used - period : 28 days for two cycles(actually 9 days) - liquid waste generated : 465 ft^3 -	

2.4 Decontamination process

If the preparation of all technologies and its procedures were finished, those would be applied to the practical field work. The Figure 2 shows the general task flow.

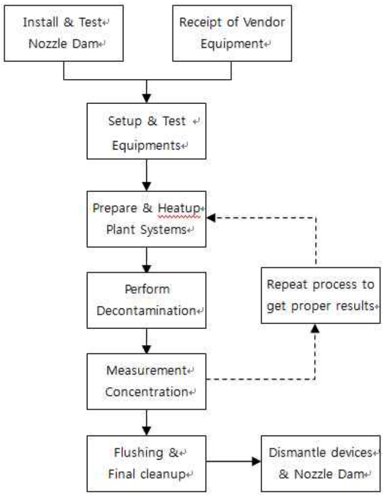

Fig. 2. Process flow of the decontamination

If large components are excluded from decontaminated items, the nozzle dams has to be installed to connect hot legs and cold legs at first. Then, decontamination equipments would be set up with RCS systems. According to the technology, existing equipments in NPP can be used with the vendor-supplied equipments for the decontamination. This equipments consist of a circulating pump, heater, filter, chemical injection system, restoration system(ion exchange system in EPRI DFD, UV burning system in CORD D UV) and the connecting tools like pipes and hoses. While any existing equipment was not used in Maine yankee decontamination, an RHR pump, the pressurizer heaters, and the plant demineralizers were used to support systems in Connecticut Yankee case.

The decontamination of Maine Yankee NPP was performed in two separate applications using temporary equipment external to the station systems. The flow path for Application 1 included the CVCS, portions of the RCS, and the pressurizer along with its spray lines. The flow path for Application 2 included the RHRS and the RCS in total.

Table 4. Decontamination schedule of Maine Yankee NPP

Description of process	Start	End	Step Duration	Project Duration
Receipt of equipment	1/26/98	2/2/98	8	8
Setup & Test tools	1/27/98	2/10/98	15	16
Install Nozzle Dams	2/3/98	2/7/98	4	16
1st Prepare systems	2/10/98	2/14/98	4	20
Perform 1st App.	2/14/98	2/23/98	8.5	28.5
2nd Prepare systems	2/23/98	2/26/98	3.5	32
Perform 2nd App.	2/27/98	3/6/98	7.5	39.5
Final Clean-up	3/6/98	4/3/98	27.5	67

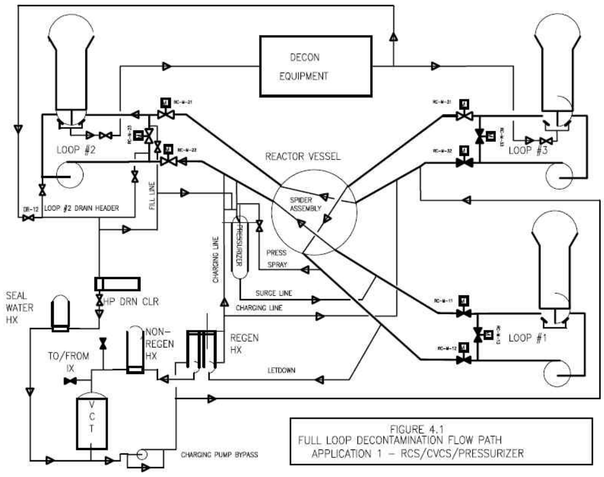

Fig. 3. Flow path of Application 1 in Maine Yankee

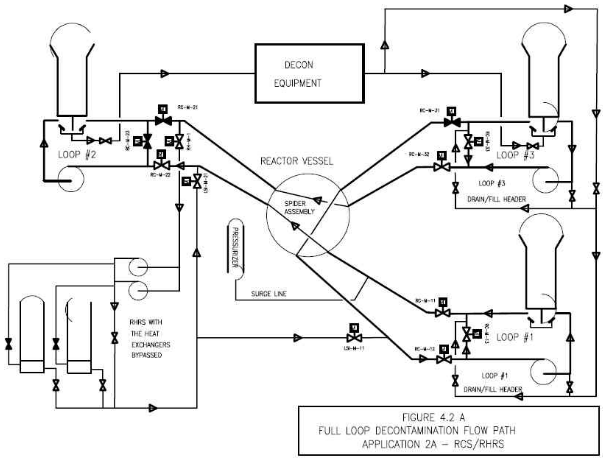

Fig. 4. Flow path of Application 2A in Maine Yankee

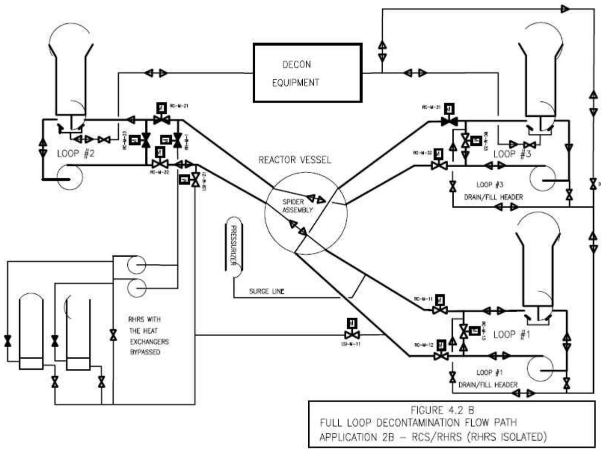

Fig. 5. Flow path of Application 2B in Maine Yankee

Unlike Maine Yankee, the decontamination of Connecticut Yankee was performed in a single application using a combination of existing plant equipment as well as temporary equipment external to the station systems. The vendor-supplied equipment was added between the discharge of the RHR pump and the line added to the pressurizer.

Table 5. Decontamination schedule of Haddem Neck NPP

Description of process	Start	End	Step Duration	Project Duration
Install NZL Dams	5/29/98	6/25/98	27	27
Receipt of equipment	6/17/98	6/30/98	13	32
Setup & Test tools	6/19/98	7/6/98	17	36
1st Prepare systems	7/7/98	7/25/98	18	57
Perform 1st Cycle	7/26/98	8/8/98	13	71
2nd Prepare systems	8/8/98	8/10/98	2	73
Perform 2nd Cycle	8/10/98	8/21/98	11	84
Final Clean-up	8/21/98	9/28/98	38	122
Dismantle Equipment	8/24/98	9/3/98	10	
Equipment off site	9/22/98	9/23/98	2	
NZL Dams removed	10/20/98	10/23/98	3	

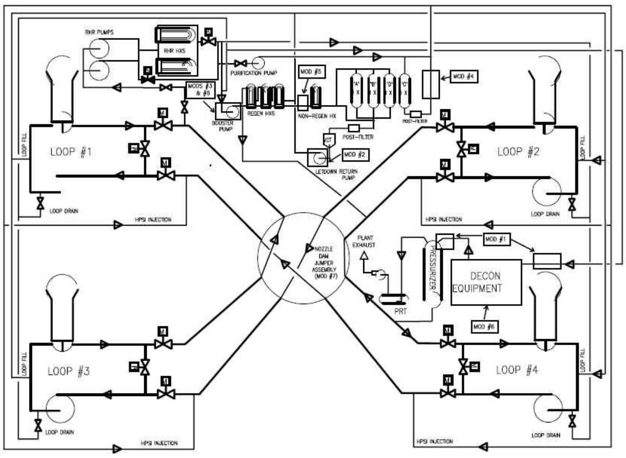

Fig. 6. Flow path of RCS full loop in Connecticut Yankee

2.4 Factors influencing cost

- Equipments (pumps, heat exchangers, tanks, connecting pipes, valves, monitoring devices, and etc)
- Worker (chemist, specialist, engineer, and day-to-day worker)
- Materials (acid, ion resin, consumables, and etc)
- Other Cost (profit of contractor, tax, and etc)

3. Conclusions

For the planning of the decontamination, there are several important decisions to be made as follows :

- whether the large components are included in the decontamination items or not
- whether there are a delay factors like the fuel failure
- what items applied to before/after decontamination
- applied technologies
- using what equipments

The decontamination plan is not fixed. It can be changed by the circumstances of progress. The schedule can be shortened by the good efficiency. Eventually, the manager who make a plan have to keep such factors in a mind.

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