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Analysis of Major Decommissioning Works Process in Nuclear Power Plant

Min Seong Kim, Ji Woo Kim, Jong Hyeok Park, Kwang Pyo Kim*
Nuclear Engineering Dep.t, Kyung Hee Univ., Gyeonggi-do, Korea
**Corresponding author: kpkim@khu.ac.kr*

1. Introduction

In 2017, Kori Unit 1 was permanently shut down, and about 10 nuclear power plants are expected to be shut down by 2030. Accordingly, in Korea, preparations for the decommissioning of nuclear power plants are in progress, and research on the decommissioning work is also being performed.

There are many different types of works in decommissioning a nuclear power plant, and they can accompany exposure of workers. Therefore, it is necessary to analyze the major decommissioning works that may have a radiological effect on the workers. In this regard, the NRC suggests that reactor vessel internals (RVIs) segmentation and steam generator removal are the major works that can have a radiological effect on the workers [2]. The RVIs and steam generator are expected to have high radioactivity compared to other wastes, and are likely to have high radiological effect. Therefore, the dose assessment for the works must be performed, and the analysis of RVIs segmentation and steam generator removal process must be preceded for dose assessment.

In this study, we analyzed the major decommissioning works process in nuclear power plant.

2. Overview of decommissioning works

IAEA (International Atomic Energy Agency) published SRS-77 to suggest that there are many differences between the main works of nuclear power plants during operation and decommissioning [1]. In the operation work environment, the location of sources and radioactivity are known, so the exposure dose of workers can be assessed relatively accurately. However, in the stage of decommissioning the nuclear power plant, the location of the radiation sources and the radioactivity continuously change, so the working environment of the worker cannot be clearly identified. Therefore, in order to determine the radiological effect of the decommissioning workers, it is necessary to select the major decommissioning works preferentially that are expected to accompany radiological effect.

In this regard, US NRC (Nuclear Regulation Commission) published NUREG-0586 to suggest decommissioning works that could potentially accompany exposure. According to the types of works, there are works performed even during maintenance and operation, and those considered only when decommissioning. Table 1 shows the major decommissioning works which accompany exposure.

Table 1: The major decommissioning works which accompany exposure

Categories	Specifics
Removal of nuclear fuel	• Transported to the spent fuel storage tank • Primary system drainage • Liquid treatment
Chemical decontamination of the primary system	• Cutting, injecting and discharging chemicals, and cleaning
Remove large instruments	• Removal or cutting of reactor vessels and internals • Removal or cutting of steam generator and other parts
Deferred Dismantling	• System and radiation level monitoring • Prevention and maintenance of structures, systems, and devices
Decontamination and Dismantling	• Chemical decontamination • Decontamination of inner wall of pipe • High-pressure water spray on the surface • Removal of contaminated soil in a specific area • Prevention and maintenance of structures, systems, and devices
Decommissioning systems	• Cutting of radioactive pipes • Removal of tanks and other radioactive structures
Shielding containment	• Engineering barrier installation • Blocking the operating system • Removal of all radioactive materials outside the containment building • Location of materials within the containment building • Lowering the ceiling of the containment building
Transportation	• Large instruments • Low-level radioactive waste

3. Major decommissioning works process

3.1 Reactor Vessel Internals Segmentation

Fig 1 shows the schematic diagram of RVI [3]. RVIs consist of upper and lower parts, and offers fuel support and protection for the reactor vessel by absorbing excess radiation. In general, RVIs have been activated due to neutrons irradiation for several decades. The wastes are expected to have very high radioactivity compared to other wastes, and underwater segmentation is preferred to prevent worker exposure.

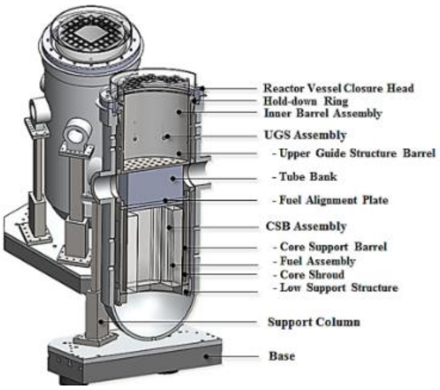

Fig 1. Schematic diagram of RVI

Table 1 shows the main procedures of the RVIs segmentation. RVIs segmentation work is largely divided into 1) upper cutting and 2) lower cutting. The upper and lower cutting work use cutting techniques such as band saw, disc saw, plasma cutting, contact arc metal cutting and disassembling tool. The segmentation starts from the upper region to the lower region.

Table 1: The process of RVIs segmentation

Categories	Process
Upper cutting	1. Disassembling the guide tube 2. Coarse cutting, disassembling, and Interim storage of the upper RVIs in upper cavity region 3. Fine cutting and loading/packaging of segments in lower cavity region 4. Cutting of upper core plate
Lower cutting	1. Coarse cutting of upper cavity region using contact arc metal cutting, plasma cutting, and fine cutting 2. Interim storage of the segments in upper cavity region 3. Segmenting, transporting, loading, and drying the waste package in lower cavity region 4. Cutting of the baffle plate, baffle former, barrel, thermal shield, and lower core plate - main radionuclides: ^{60}Co, ^{59}Ni, ^{63}Ni

3.2 Steam Generator Removal

The steam generator exists in the primary system of a nuclear power plant, and activated for several decades. So, the steam generator has a high level of radioactivity. In addition, the size of steam generator is very large, so it generates a lot of metal radioactive wastes. However, it is necessary to understand the decommissioning process because the steam generator is complicated in shape and difficult to treat [4].

Table 2 shows the steam generator removal process. The steam generator removal process can be divided into 1) pipe cutting and 2) steam generator cutting. In the case of pipe cutting, it is performed for facilitating removal the steam generator, lifting and removing the upper and lower shells. and the steam generator is removed through the step-by-step steam generator cutting procedure.

Table 2: The process of steam generator removal

Categories	Process
Pipe cutting	1. Removal many types of small-bore pipe (ex. blowdown pipe) for facilitating removal of steam generator 2. Cutting upper shell and downstream steam pipe for lifting the upper shell 3. Cutting water supply pipe connected with upper shell for removing upper/lower shell 4. Cutting and removing reactor coolant inlet and outlet pipe
Steam generator cutting	1. Cutting lower parts of steam generator 2. Cutting steam generator shell in transition cone 3. Cutting steam generator wrapper
Others	1. Separating upper shell using crane 2. Decontaminating internals and cutting divider plate in containment

4. Conclusion

In this study, we investigated the major decommissioning works of nuclear power plant. As a result, RVIs segmentation and steam generator removal process apply different strategy according to the characteristics of instruments such as shape, structure, etc.

Because the decommissioning workers work in an unspecified environment, it is necessary to establish an exposure scenario according to process of decommissioning to calculate the exposure level accurately. The results of this study can be used as a basis for dose assessment of the nuclear power plant decommissioning workers.

ACKNOWLEDGMENTS

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