

A Preliminary Study on Work Difficulty Factor of Decommissioning in Korean Nuclear Power Plants

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1. Introduction

Decommissioning of nuclear facilities refers to all activities under the Nuclear Safety Act [1] by permanently suspending the operation of nuclear-related facilities that have been licensed or designated, and then removing the relevant facilities and sites or removing radioactive contamination. Nuclear power plant (NPP) decommissioning requires the execution and management of a large number of tasks as well as of the management of a large number of resources (materials, humans, and finance). In order to calculate the NPP decommissioning cost estimate, the calculation should be based on the components of the objects of the decommissioning facility and the cost items for the decommissioning work activities. However, as decommissioning processes have many unclear assumptions and standards for decommissioning cost are varied the uncertainties of the decommissioning data and cost are high. Therefore, it is necessary to classify the decommissioning work according to the characteristics of the decommissioning facility and object using a reasonable engineering cost calculation method.

Generally, the procedure for calculating NPP decommissioning cost estimate should comprehend the components of the facility and the radioactive characterization, and estimate all types of the cost according to the decommissioning procedure. Typical types of cost estimates are labor costs, equipment, material costs, and contingency costs. Labor costs can be calculated based on the work time required for Work Break Structure (WBS), and the others costs can be evaluated by calculating the equipment and material costs and contingency. The labor costs among them have to consider Work Difficulty Factors (WDF). The WDF refers to a factor that causes work delay due to factors that cannot be avoided other than the average time required to perform a specific decommissioning work and is expressed as a percentage of work time increase. By well-defining the WDF, it is possible to more accurately calculate the cost of labor costs among the decommissioning costs, and this can lead to the reduction of unnecessary decommissioning costs [2]. Therefore, the accurate setting of the WDF is a very important factor in calculating the decommissioning cost. Certain countries which are leading the nuclear industry have already had a number of decommissioning experiences, and the decommissioning cost was evaluated by establishing a systematically defined WDF

in advance. Also, the WDF was verified through a number of decommissioning cases. However, Korea has no experience in decommissioning, and a WDF suitable for domestic situations has not been established. The determination of the WDF is urgently required to estimate the cost for the decommissioning of Kori Unit 1, which will soon be decommissioning.

In this study, to calculate decommission cost of the Korean nuclear power plant, the WDF in labor costs is suggested that meet domestic situations.

2. Methods and Results

2.1 Work Difficulty Factor

The WDF was introduced to enhance the credibility and thoroughness of cost estimates by providing a detailed breakdown of costs to measurable, comprehensible levels in order to ensure that all estimates related to labor cost will properly be identified and accounted for all activities and elements. The AIF/NESP-036 report has recommended using the WDF when estimating labor costs. This report proposed that five factors are presented as WDF, factors are height factor, respiratory protection factor, radiation/ALARA factor, protective clothing factor, and work break factor as shown in table I. Each WDF can have different application rates according to country and work activities. [3].

Table I. Work Difficulty Factor in AIF/NESP-036 Report

Classification	Factor	Additional Rate
A	Height Factor	10~20%
B	Respiratory Protection Factor	25~50%
C	Radiation/ALARA Factor	10~40%
D	Protective Clothing Factor	15~30%
E	Work Break Factor	8.33%

2.2 Additional Allowance for Working Time

Standard cost estimates according to processes have already been systematically established in business fields other than decommissioning of a nuclear power plant in Korea (e.g., construction, civil engineering, machine equipment, and engineering, etc.), and additional allowance for working time has been introduced and applied. In the cost estimate, the additional allowance for the working time for each item is applied in consideration of the construction scale and

site conditions to estimate the appropriate cost. Table 2 describes additional allowance for the working time [4].

Table II. Additional Allowance for Working Time

No.	Factor	Additional Rate
1	Work Efficiency Factor	0~20%
2	Work in Mountain Area Factor	0~50%
3	Factor by Train Frequency	3~37%
4	Night Work Factor	0~25%
5	Small Size Work Factor	0~50%
6	Work Factor by Geography	0~50%
7	Work Factor by Terrain	0~50%
8	Risk Work Factor	10~80%
9	Work Factor by Building Floors	1~7%
10	Work Factor by Hazard	10~30%
11	Special Work Factor	5~10%
12	Work Time Limit Factor	0~35%
13	Etc. Work Factor	0~50%
14	Factor by Move Inconvenient	0~50%
15	Factor for NPP Construction	No Decided*

* In the case of processes in which the quality and safety inspection for each work stage is strictly applied in nuclear power plant construction, a work premium is added separately for each process.

2.3 Suggestion of Work Difficulty Factor in Korea Decommissioning Process.

In order to carry out the decommissioning of the upcoming Kori Unit 1, it will be necessary to set the WDF to estimate the decommissioning cost considering the Korean nuclear situation. However, in the domestic nuclear field, there is no standard cost estimate, and the WDF has also not been established. The additional allowance for working time is very similar to the WDF. Therefore, it is necessary to introduce an additional allowance for working time or alternative to the WDF in the estimate in the domestic nuclear field, which has not been systematically established yet. This is because the inclusion of the nuclear field in the standard product calculation already established in Korea can have socio-economic advantages, and it is possible to estimate the labor cost more accurately and reliably by setting the Korean WDF suitable for the domestic decommissioning situation. As a part of the effort, the factors applicable to Korean WDF were analyzed for the aforementioned 15 additional allowances for working time, and the results are shown in Table III.

Table III. Comparison Existing WDF and Additional Allowance for Working Time Factors for domestic WDF Application

No.	WDF	Additional Allowance for Working Time Factors
1	Height Factor	Risk Work Factor
2	Respiratory Protection Factor	Etc. Work Factor
3	Protective Clothing Factor	
4	ALARA Factor	Work Factor by Hazard

5		Work Time Limit Factor
6	Work Break Factor	-
7	-	Special Work Factor

Results show that the factors required as WDF among the additional allowance for working time are risk work factor, etc. work factor, work factor by hazard, work time limit factor, and special work factor. Since it is a work adjustment factor in the process of constructing a nuclear power plant, it is not applicable during the decommissioning process, so the factor for NPP construction was excluded from the list. The respiratory protection factor and protective clothing factor were integrated into Etc. work factor because they are overlapped with each other. In addition, the special work factor about work that must be accompanied by a supervisor for work with special work conditions is not considered in the WDF recommended by IAEA, so it was contained in the list.

3. Conclusions

In this study, the additional allowance for working time of Korea similar to the work difficulty factor recommended by the Atomic Industrial Forum, Inc. (AIF) was analyzed, and applicable factors were derived in the decommissioning process of Korean nuclear power plants. The results were analyzed that it would be more appropriate to consider the risk work additional allowance, etc. work additional allowance, additional allowance work factor by hazard, and special work additional allowance as work difficulty factors. In the future, a conformity evaluation for the proposed Korean work difficulty factor and its premium rate will be performed.

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