Development of Cost Estimation Methodology of D&D(Decontamination and Decommission) for CANDU Reactor

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1. Introduction

The 50 % of the operating nuclear power plants in the world is expected to be closed by 2030, which means to create a substantial market for the nuclear reactor decommissioning [1, 2].

Decommissioning is the complex process to decontaminate, dismantle, demolish and dispose the nuclear power plant system to return to site reuse or rehabilitation. That is why the decommissioning takes the longer time than the construction. Also, the permanent closure of nuclear power plant should be conducted with the strict laws and the profound planning including the cost and schedule estimation because the plant is very contaminated with the radioactivity.

In Korea, there are two types of the nuclear power plant. One is the pressurized light water reactor (PWR) and the other is the pressurized heavy water reactor (PHWR) called as CANDU reactor. There are many studies about the decommissioning of PWR but are few studies about the decommissioning of CANDU reactor.

The purpose of this paper is to develop the cost estimation methodology of decontamination and decommissioning (D&D) for the application to CANDU reactor based on the system engineering technology [3].

2. Methods and Results

2.1 Methodology

System engineering is the interdisciplinary field of engineering that focuses on how to design and manage complex engineering projects over their life cycle. This deals with work-process, optimization methods, and risk management tools in such projects and ensures that all likely aspects of a project or system are considered, and integrated into a whole [3]. In order to apply the system engineering to the development of the cost estimation methodology of D&D, the following scopes should be considered:

- Survey basic information of the plant
- Select the decommissioning scenarios
- Decide D&D scope
- Define the bill of material (BOM) of D&D
- Develop work breakdown structure (WBS) including activities and cost information
- Search unit cost reflecting Korea labor productivity

In order to model the scenario-based WBS and SET structure, this paper uses the data modeling, process modeling and the object oriented modeling. The basic structure of this methodology is task structure, set structure and work unit library that incorporates labor and waste information.

As shown in Figure 1, this methodology consists of set, subsets, tasks and subtasks which are incorporates more than one work unit.

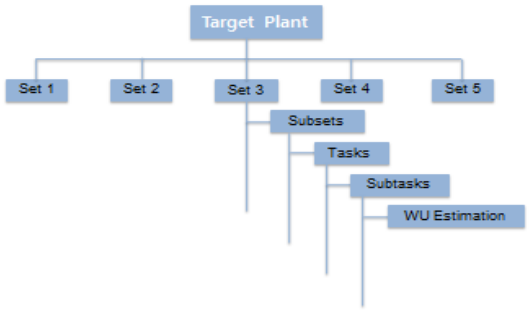

Figure 1 Decommission Work Outline of Nuclear Power Plant

2.1 Structure of the Modeling

2.2.1 SET Structure

SET structure represents the scope definition of target plants. Superset means the target plant such as CANDU. The Superset (or target plant) incorporates several Sets that are defined as buildings and/or facilities. Each Set includes several subsets. Each subset mainly are applied to floor of the building of each Set. For example, site power and property taxes are listed in Set 1 (Management & Support) since these items should be considered for any project cost estimate. Regarding containment building, five (5) Subsets are available: Below slab EL.100, Slab EL.100 to Slab El.122, Slab EL.122 to Slab EL.142, Slab EL.142 & above and containment building general [4]. This space classification may depend on estimator's judgment. SET structure is derived from site specific general arrangements and plant configuration. Table 1 shows the result of SET

structure of CANDU reactor. The SET of CANDU reactor consists of 21 SETs including management, support, the major buildings and facilities.

Table 1 SET structure of CANDU reactor

No	SET	No	SET
1	Management & Support	12	Emergency Facility & Equipment
2	Service Building	13	Under Ground Utilities
3	D_2O Upgrading Facility	14	Turbine Building
4	Reactor Building	15	Gas Storage Area
5	SF Dry Storage Handling Facility	16	Water Purification Building
6	Guard House	17	Water Treatment & Storage Facility
7	Cooling Water Facilities	18	Meteorological Station
8	Yard Transformer Area	19	Common Buildings
9	Main Steam Structure	20	Site Restoration
10	Switch Yard	21	Spent Fuel Facilities
11	Auxiliary Steam Facilities		

2.2.2 TASK Structure

Each task should be allocated into SET structure since the decommissioning of each buildings and facilities needs the tasks. Each task consists of each subtask depending on the details of the task. For example, some subtasks for dismantling mechanical in containment building are defined as steam generator removal, CANDU pressure vessel removal, tank removal, surface decontamination and auxiliary mechanical equipment removal. And the subtask list for other buildings is different [4]. Decision on subtasks is based on applicable D&D works on each SET and SUBSET structure.

2.2.3 Work Unit

The Work units are generally developed to identify the lowest possible working level of the manpower, materials and equipment that may be needed to perform the identified work. It provides a basis for the estimation of cost unit of D&D work. Therefore, Wok unit incorporates library information of labor and waste information. In this paper, some Work units are based on the information from the Korean experience of CANDU reactor and the ASME data [5] for estimating the decommissioning costs of CANDU reactor.

2.3 Result

Figure 2 shows the preliminary results of the decommissioning cost and schedule of Wolsong Unit 4. To get the result of CANDU NPP, the SET Structure is generated as 21 SET lists. Task structure is formed as 15 categories with each SUBTASK. The preliminary result shows that the project durations and the required actual man power are 5 years and 1,313 days, respectively.

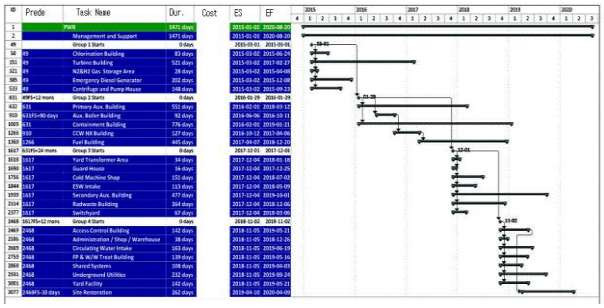

Figure 2 Result of cost and schedule estimation for CANDU reactor

3. Conclusions

The aim of present study is to develop the cost estimation methodology of D&D for application to CANDU reactor. Through the study, the following conclusions are obtained:

- Based on the system engineering, the D&D work can be classified as Set, Subset, Task, Subtask and Work cost units.
- The SET and Task structure are grouped as 21 sets and 15 tasks, respectively.
- The final result shows the cost and project schedule for the project control and risk management.
- The present results are preliminary and should be refined and improved based on the modeling and cost data reflecting the current labor and waste data.

REFERENCES

[1] “Closing and Decommissioning Nuclear Power Reactors,” UNEP YEAR BOOK 2012.
[2] Laura Wood, “Research and Markets: Nuclear Reactor Decommissioning Industry - Global Market Size and Competitive Landscape Analysis to 2030,” August 31, 2013.
[3] G. A. Hazelrigg, “System Engineeing : An Approach to Information-Based Design”, Prentice-Hall, 1996.
[4] Sun-Kee Lee, “Cost Estimating System Development for Decommissioning Nuclear Power Plants Lessons Learned from Korean Cost Estimate Project – 10196.” March 7-11, WM Conference, Phonix, AZ., 2012
[5] The Decommissioning Handbook, ASME, 2004.