Case Study to Apply Work Difficulty Factors to Decommissioning Cost Estimates

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1. INTRODUCTION

In respond to the Korean government's decision in June 2015 of the permanent shut-down of Kori-1 nuclear power plant, Kori-1 unit will be the first commercial nuclear power plant being decommissioned in Korea, which has generated the capacity of 576 MWe electricity capacities since 1978, plus a refurbishment for 10-year continued operation. This article is prepared as a guideline regarding how to apply the work difficult factor (WDF) when it comes to the estimates of the decommissioning costs.

Although several cases of the decommissioning cost estimates have been made for a few commercial nuclear power plants, the different technical, site-specific economic assumptions used make it difficult to interpret those cost estimates and compare them with that of Kori-1. In addition, it is clear that we are supposed to experience difficulties being created in the process of the Kori-1 and the virtual inaccessibility to the limited areas at the pre-decommissioning stage. Hence we had to refer to some of the previous cases and approaches suggested by the guideline by AIF/NESP-036[1][1].

2. COST CATEGORIES

In order to estimate reasonable WDF, firstly, cost categories shall be understood [1]. They are largely composed of three cost categories; *activity dependent costs* which are directly related to discrete activities, for example, decontamination, removal, packaging, shipping and disposal including all labor, materials, energy, equipment and services (shipping and disposal) associated with the hands-on activities, *period-dependent costs*, those in associated with project management, administration, routine maintenance, radiological, environmental and industrial safety and security which are not directly able to be assigned to activities respectively, but are essentially period-dependent, for instance, these costs continue for the duration of the decommissioning period, *collateral or special item costs* are typically one-time costs that are neither attributable directly to respective specific decommissioning activities, nor period-dependent including items such as heavy equipment purchase, health and safety supplies, energy costs (heating, diesel fuel, gasoline, etc.), taxes, and regulatory licenses and insurances.

[1] Guideline for producing commercial nuclear power plant decommissioning cost estimate, AIF(American Industrial forum) Inc.

Among those three categories, WDFs could be assignable to the activity dependent costs which are articulate into the unit of each activity while the other two costs are either lingered over long term period or purchased on a spot basis when needed.

3. APPLICATION OF WDFs TO PROCESS OF ESTIMATING DECOMMISSIONING

There are five steps to estimate activity dependent costs using WDFs; first, determine the scope of the target SSCs (Structure, System and Components) and calculate critical work duration, second, adjust the critical duration using WDFs, third, figure out the labors needed, fourth, apply the costs of equipment and consumables used, and finally, estimate the total cost for the target SSC decommissioned.

3.1 Work difficulty factors

The application of the WDFs intends to increase productivity losses associated with working in difficult or hazardous environment. This approach has been widely used at operating plants to consider difficulties in performing maintenance activities during the planned outages. In the process of WDFs estimation, the critical work and its duration could be inferred. Five WDFs are the stereo types considered in estimating the decommissioning costs per unit of work;

$$WDF_i = f(A_i, R_i, Ra_i, P_i, B_i)$$

where, A_i is the accessibility adjustment factor, R_i the respiratory protection adjustment factor, Ra_i is the Radiation/ALARA adjustment factor, P_i is Protective clothing adjustment factor and B_i is the work break adjustment.

Accessibility Factor intended to account for the limited degree of motion possible under the working environments reduces the worker productivity such as working on scaffolding, on ladders, in pipe tunnels, or in other confined spaces. The access factor ranges are assumed ranging from 10% to 20%. *Respiratory Protection Factor* to account for breathing difficulty, obscured vision due to the mask window and fogging, and stress from the straps around the head. The respiratory protection factors are assumed ranging from 0% to 50%. *Radiation or ALARA Factor* to account for the time spent preparing for an entry into a high radiation or high controlled area. This time is used to alert the crew the potential hazards in the area, the specific activities to be accomplished while in the area,

and emergency procedures to be implemented for immediate evacuation. This factor also accounts for the periodic training the crew would take part in to maintain their radiation training and certification. The ALARA factor ranges in this study from 0% to 37%. *Protective Clothing Factor* to account for the time and worker needs to put on protective clothing for each entry and exit from a radiation control area. Typically, this represents four changes per day. The protective clothing factor ranges in this study from 0% to 30%. *Work Break Factor* intended to account for the time a worker needs to take a morning break, a lunch break, and an afternoon break. A work break factor of 8.33% has been used.

3.2 Labor rates

The possible crew members for the decommissioning activities normally, are laborers, craftsmen, general foremen, fire protection, health physics technician and the like. However, all of the crew members are not committed to all tasks simultaneously; for example, a health physics technician is not needed for removal of clean equipment. These total labor cost is calculated by the adjusted total work duration, the number of workers and their salary.

3.3 Equipment and consumables cost

For each task some equipment and consumables might be needed such as gas torch consumables used for pipe cutting. In addition, overhead and profits are added to the summarized equipment and material costs. Finally the total cost for labor and material costs is summarized

4. CASE STUDY

We assume the virtual target component as the heat exchangers weighing less than and not equal to 1,559 kg will be removed in one piece using a crane or small hoist. They will be disconnected from the inlet and outlet piping. The heat exchanger will be sent to the waste processing area. For the next step, we calculate the work duration for the heat exchangers [2].

Table 1. Calculations of Work Duration

Activity Description	Activity Duration	Critical Duration
Remove insulation	80	(T)
Mount pipe cutters	80	80
Install contamination controls	30	(T)
Disconnect inlet and outlet lines	80	80
Cap openings	30	(T)
Rig for removal	40	40
Unbolt from mounts	40	40
Remove contamination controls	20	20
Remove, wrap in plastic, send to packing area	80	80
Totals (Activity/Critical)	480 min	340 min

(T) activities can be done at the same time

We put percentage WDFs in to adjust the critical duration calculated in Table 1 into duration adjustments.

$$DA_i = CD_i * [(1 + (A_i + R_i + Ra_i)(1 + P_i)(1 + B_i)]$$

where, DA_i is duration adjustment and CD_i is critical duration calculated.

Table 2. Duration Adjustment

Duration adjustment of critical duration	**min.**
+ Access adjustment (0 %)	0
+ Respiratory protection adjustment (45 %)	153
+ Radiation/ALARA adjustment (35 %)	119
Adjusted work duration	**612**
+ Protective clothing adjustment (25 %)	85
Productive work duration	**697**
+ Work break adjustment (8.33 %)	28
Total work duration	**725 (12hr)**

Table 3. Labor Costs

Crew	**Number**	**Duration (hr)**	**Rate ($/hr)**	**Cost ($)**
Laborers	3.00	12	55.29	663.53
Craftsmen	2.00	12	76.47	917.65
Foreman	1.00	12	86.53	1002.35
General Foreman	0.25	12	91.76	1101.18
Fire Watch	0.25	12	55.29	663.53
H.P Technician	1.00	12	54.11	649.41
Total labor cost				**4997.65**

Table 4. Equipment & Consumables Costs

Equipment	0
Consumables/Materials Costs	20
Subtotal cost of equipment and materials	15
Overhead & profit on equipment and materials @ 10.0% (excluding VAT)	18
Total costs, equipment & material	**52**

Table 5. Total Costs

Total labor cost:	4997.65
Total equipment/material costs:	52
Total costs($)	**5049.89**

5. CONCLUSION

Estimating decommissioning costs is one of the most crucial processes since it encompasses all the spectrum of decommissioning activities from the planning to the last evaluation on whether the decommissioning has successfully been proceeded from the safety and economic perspectives. Here I suggested the activity dependent costs is only related to WDFs of the incumbent plant planning or undergone to be decommissioned since as a matter of fact, estimating WDFs is the core process to articulately scrutinize the practical costs to apply to Kori-1 project. In addition to the estimating process suggested in Chapter 4, we have assignments to supplement the cost estimates process in more detail the course of decommissioning project.

REFERENCES

[1] Daniel et. al (1986), “Guideline for producing commercial nuclear power plant decommissioning cost estimates”, AIF/NESP-036

[2] Tommy et al. “An assessment of the decommissioning cost for the Ringhals site”, R-13-05