Status of unit cost factor development for nuclear facilities in KAERI

Seungkook Park, Hyung Gon Jin*, Chang Wook Shin

Korea Atomic Energy Research Institute, Republic of Korea
**Corresponding author: jhg@kaeri.re.kr*

1. Introduction

This paper describes the status of UCF (unit cost factor) development for estimating the cost of decommissioning nuclear facilities in the KAERI site. One of key elements of cost estimation is the UCF, however, it highly depends on contamination of the site. The data base for the activities encountered for each operation is well documented from many years of similar experience on familiar equipment. Re-organizing the KAERI experienced data and open literature has been performed. The existing decommissioning data bank is insufficient information to extrapolate this experience to develop credible decommissioning cost estimates. But this work is meaningful approach to build Korean standard UCF system.

2. General Approach

The types of unit factors development are those that require detailed knowledge of activities learned through decommissioning experience. Some of this activity information is from first-hand experience of the authors, industry engineers, health physicists and technicians. The guide lines for unit factors were collected from personal experience, and from reported experience in the literature of other similar or related programs. The experience of the authors was used to collect and evaluate or modify industry experience to reflect current site practices, regulatory restrictions and tooling /equipment factors.

3. Development of Unit Cost Factor

There are three types of unit factors developed in this section. The type and purpose of each are described in the following paragraph [1].

1) Removal of clean components

These factors will apply to the removal or demolition of components or structures that are not contaminated or activated. The items are assumed to be transferred to a loading dock for disposal as salvage, scrap or landfill burial.

2) Removal of contaminated/activated components

These factors will apply to the removal or demolition of that are contaminated or structures components or activated. The factors include the necessary precautions, special equipment and remote handling required to minimize radiation exposure and prevent the spread of contamination. The items are assumed to be transferred to a loaded into a shipping container and packaging area, ultimately shipped to a controlled burial site.

3) Removal of non-routine Equipment

These factors will apply to the removal of the reactor steam generators, pressurizer, internals, vessel and activated/contaminated concrete and concrete wall/ floor, turbine generators, condensers, turbine-driven pumps, transformers, diesel generators and cooling towers. Some of the guidelines for items in this category will be on a unit factor basis such as concrete removal and others will be on a total labour hours' basis, such as the reactor vessel and steam generator. For vessels and internals, the number of sub-activities is complicated by considerations of curie, weight and volume-limited shipments.

비목	Activity			소요시간(hr)	
				Activity	Driving
작업소요시간	(a)	단열재 제거		5.000	5.000
	(b)	폼 설치		5.000	5.000
	(c)	오염 제거 장치 기기 설치		5.000	5.000
	(d)	파이프 절단		5.000	5.000
	(e)	폼 제거		5.000	5.000
	(f)	파이프 끝에 캡을 씌움		5.000	5.000
	(g)	오염 제거 장치 장치를 제거하고 폐기를 위해 밀폐		5.000	5.000
	(h)	아적 공간에서 제거하기 위해 이송 컨테이너에 파이프 적		5.000	5.000
	작업기준시간			40.000	40.000
	Over Head(기간조정인자)				
	높이할증	작업기준시간 대비	15%		6.000
	전면마스크방호		38%		15.200
	ALARA		15%		6.000
	기간 조정 소계				27.200
	방호복 미착용시 작업시간 (작업기준시간 + 기간 조정 소계)				67.200
	방호복착용	미착용시 대비	23%		15.456
	방호복 착용시 작업시간				82.656
	휴식시간	작업시간 대비	8.3%		6.885
	총 작업 소요 시간 (작업시간 + 휴식시간)				89.541

	직급	인수(m)	단가(₩/m-hr)	활동(hr)	금액(₩)
노무비	보통인부	2		1.492	-
	특별인부	1		1.492	-
	작업반장	0.5		1.492	-
	계				-
	간접비율 (간접노무비)			25%	-
	소계				-
	품목	단위	수량	단가(₩)	금액(₩)
직접비 (재료비)	제염지	sheet	25	630	15,750
	비닐시트, 백	EA	25	40	1,000
	가스 토치 소모품	EA	1	5,100	423
	계				17,173
	간접비율			20%	3,435
	소계				20,608
	품목	단위	수량	단가(₩)	금액(₩)
경비					
	간접비율				
	소계				
총계					20,608

	품목	단위	수량	단가(₩)	금액(₩)
장비비 (단품)					
	소계				-

Table. 1 Example of the UCF system

4. Cost Elements of Unit Factors

Unit factors are developed on a unit productivity basis, for example, labour hours per cubic meter of concrete removed, etc. The unit factor is developed so as to permit rapid estimation of costs by inclusion of the appropriate labour rates for the respective crafts, material costs and equipment purchase/rental costs. Because decommissioning is labour intensive, site-

specific labour costs should be incorporated in each unit factor. This step is left to the individual estimator to provide.

1) Labour hour estimates
In earlier studies and cost estimates were taken from actual decommissioning programs such as KRR-I/II and UCP (Uranium Conversion Plant) [2]. This earlier experience provided valuable estimation guidance as to the activities to be performed and types of difficulties that maybe encountered. While it may be argued these are research reactors that do not necessarily replicate commercial plants. The earlier decommissioning experience and factors developed from this experience were difficult to adapt to new tools, new techniques, or more stringent radiological controls required to perform an activity such as cutting highly contaminated pipe, etc. The early factors did not identify the component of activity time allocated to productive time (removing insulation, cutting pipe, etc.) The guidance developed in this work addresses work adjustment factors to account for activity duration and worker productivity, as well as new tools and techniques.

2) Labour expenses
The decommissioning crew labour can be drawn from three potential sources: utility employees, outside craft labour or subcontracted labour. The total cost for this labour must be appropriately accounted estimate for to ensure an accurate estimate is developed.

3) Materials and equipment expenses
Material, special equipment and consumables for decommissioning activity are also included in the unit factor to further simplify the estimating process. This approach is fully consistent with widely accepted cost estimating methodology for routine construction estimating.

5. Adjustment Factors for Work Durations

Work on activated or contaminated systems necessarily requires additional time for crews to provide for personnel protection and to work in a radioactive environment. Time estimates of worker productivity should recognize the inefficiencies associated with working in restrictive clothing and rubber gloves, breathing through filtered respirators, standing on ladders or scaffolding or crawling into inaccessible areas of the plant. In keeping with the ALARA principle, crews need to be briefed prior to entering a radioactive area as to the high radiation sources, exposure time limitations, shielding requirements and the assigned dismantling duties. The routine requirements of obtaining radiation work permits and work authorizations on an entry by entry basis consume a significant but necessary amount of worker productive time. In addition, organized labor agreements or company policy for paid breaks must be accounted for in a job duration.

Work on nonradioactive piping, components and structures is not as restrictive. However, there remains the difficulty of working on ladders and scaffolding, crawling into inaccessible areas and to a lesser extent daily instructions on assigned dismantling duties. Allowances should be made for paid work breaks and the time expended in transit to and from the locations.

The adjustment factors identified herein should be included in the unit factor development for all repetitive activities but only where applicable. The adjustment factors for work on radioactive equipment will necessarily be more extensive than for nonradioactive equipment. Non-repetitive activities such as equipment setup or scaffolding erection will be considered separately but will include the same or similar adjustment factors.

There are five types of adjustment factors identified herein that cover the range of difficulty expected in any dismantling project. While additional detailed breakdowns of these factors are possible, the added complexity and degree of accuracy achievable do not warrant the effort. The five types of adjustment factors are:

1. Height
2. Respiratory Protection
3. Radiation/ ALARA
4. Protective Clothing
5. Work break.

Each of these factors represent a loss in productivity. It may be necessitated by physical access limitation, mandated by radiation protection guidelines (ALARA), and/or imposed by worker management agreements. These factors should be included for work involving activities in a radiation environment. They represent actual working conditions and restrictions that prevail at essentially all nuclear power plants. The estimator, of course, has the option to modify these estimates to site-specific differences

5. Further Works

Further literature survey needs to be done and harmonization of experienced data will be performed. And cost estimation of decommissioning site in KAERI could be demonstrated by using the UCF which is outcome of this work.

6. References

[1] Atomic Industrial Forum, “Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,” National Environmental Studies Project-036 (1986).
[2] Hyung Gon Jin, S. K. Park, et. al., “Status of the Decommissioning Engineering System Code Development of KAERI in 2014,” the Korean Nuclear Society Autumn Meeting Vol.1 (2014).