Application of CERREX software for KRR-1 Decommissioning Cost Estimation

Yunjeong Hong [a*], Seungkook Park [a]
[a]*111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, 34057, Korea*
[*]*Corresponding author: hong814@kaeri.re.kr*

1. Introduction

The decommissioning of non-power-generating facilities such as research reactors, owing to worldwide distribution, is of special importance in IAEA activities [1]. To support the decommissioning cost estimation for research reactors as a part of decommissioning planning process, the calculation software, CERREX (Cost Estimation for Research Reactors in Excel), was developed within the IAEA projects.

Main objectives of cost estimation is to indicate the costs required to complete the decommissioning project and to optimize the dismantling sequence and timing and then minimize the decommissioning total costs.

There are three types of cost estimate; (i) Order of magnitude estimate, (ii) Budgetary estimate, (iii) Definitive estimate. Second of the theses types is applied to cost calculation in this paper. This was also applied to cost estimate part of preliminary decommissioning plan for Kijang construction approval.

In this paper, the methodology and procedure for decommissioning costing using CERREX software were presented and cost estimation was performed and compared with actual decommissioning cost for KRR-1(Korea Reactor Research, Unit 1).

2. Costing methodology and program

2.1 Type of cost estimate

There are three types of cost estimate that can be used, and types each have a different level of accuracy:

- Order of magnitude estimate: One without detailed engineering data, where an estimate is prepared using scale-up or scale-down factors and approximate ratios. It is likely that the overall scope of the project has not been well defined. The level of accuracy expected is -30 to +50%.
- Budgetary estimate: One based on the use of flowsheets, layouts and equipment details, where the scope has been defined, but the detailed engineering has not been performed. The level of accuracy expected is -15 to +30%.
- Definitive estimate: One where the details of the project have been prepared and its scope and depth are well defined. Engineering data would include plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams and structural drawings. The level of accuracy expected is -5 to +15%.

It is apparent from these estimate types and the levels of accuracy expected that even in the most accurate case, a definitive estimate is only accurate to -5 to +15%. The cost estimator needs to exercise judgement as to the level that the input data will support. In developing a funding bases for a project, the estimator includes sufficient contingency to account for a potential budget overrun to account for this level of accuracy [1].

2.2 ISDC

International Structure for Decommissioning Costing (ISDC) is a proposed standardized list of items for costing purposes and was developed as a common platfo rm of systematized typical decommissioning activities which should cover all types of activities identified in any decommissioning project for any type of nuclear installation, regardless of its size, composition/complexity of systems and structures and radiological conditions. The typical representative decommissioning activities are organized in 11 section. 01 to 11 sections are grouped according to following to:

- Activities of a similar nature; and
- The main phases of the decommissioning project.

It is a numbered hierarchical structure of typical decommissioning activities for any project. It is represented by a two-digit number. The system of numbering at the second level represents the subgroups of decommissioning activities in relation to the first level; the numbering is represented by the first two digits in the set of four characters, separated from the first level of numbering by a dot. Numbering at the third level is represented by the last two digits in that set of four characters, as follows:

1st level	04	Dismantling activities
2nd level	04.0500	Dismantling of main process…
3rd level	04.0501	Dismantling of reactor …

The cost associated with each activity of the ISDC structures may be subdivided according to four cost categories in Fig. 3.

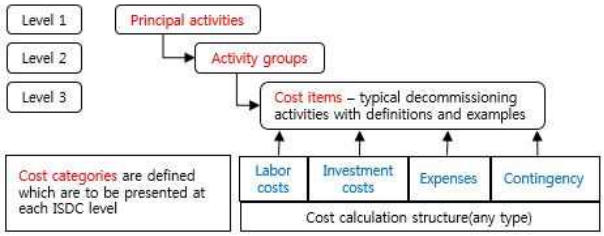

Fig. 3. Hierarchical Structure of the ISDC [2].

2.3 CERREX Software

The costing methodology implemented in the software CERREX is based on the use of the International Structure for Decommissioning Costing (ISDC). The costing calculation is done by a parametric approach, using unit factors. The software has been created in order to make estimation at two levels; a basic estimation according to 'level 1' or 'level 2' in [1] can be carried out initially, and a more detailed estimation using 'level 3' is possible when more information is available. The objective of CERREX is to provide a tool for robust cost estimates for research reactors based on the ISDC. Structure of the CERREX software consists of four sheets;

- **Inventory**: inventory database and the generated waste partitioning, including legacy waste
- **Cost Table**: three summary tables with results of calculation in ISDC format
- **Procedures**: list of inventory dependent and waste management procedures [3].

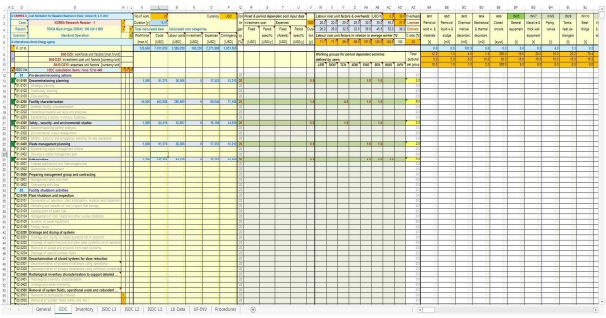

Fig. 2. Spreadsheet of CERREX software.

2.4 Costing Calculation Process

In order to perform cost estimation by CERREX, it is necessary at first to collect and analyze of inventory data on KRR1 reactor. For this inventory database tool was developed in Slovak. It is manufactured to be easy to handle for users as Excel program. Physical and radiological characterization of inventory are covered in this tool. For that purpose, an inventory database template in Excel was used including building-floor-room structure data of the facility and detailed equipment inventory parameters. Equipment parameters, the type of data, were represented in the below.

1. Identification data – equipment designation, allocation within the facility structure and technological system, relevant ISDC No.
2. Physical inventory data – mass, surfaces, CERREX category of equipment and dominant material.
3. Hazards inventory data – hazardous material and possible hazardous waste
4. Radiological inventory data – internal/external contamination, activation, dose rate and corresponding radionuclide vectors and references dates
5. Calculation data – recalculation of radioactivity in time and determination of resulting waste volumes.

At second, the further steps regarding development of model decommissioning costing case in the CERREX code should be briefly summarized as follows:

1. Implementation of the inventory database to the CERREX, i.e. definition of relevant partitioning coefficients for defined waste categories;
2. Definition of input parameters (duration, composition of the workgroup, expenses or investments) for period dependent activities;
3. Definition of calculation parameters (e.g. labor rates, manpower unit factors and cost unit factors, work difficulty factors) respecting the ISDC methodology,
4. Analysis of the obtained results – basic calculation case;

3. Results

Cost estimation for KRR-1 was carried out applying to CERREX software. Table 1 shows the result values of the calculation. The currency was calculated as USD. Calculated cost is within the limit of 'Budgetary estimate' and the values is approximately $7,800,000. Labor costs are calculated based on manpower components per involved professions and hour rates per typical professions. Investment costs and expenses are calculated using the specific cost unit factors for investment and for expenses related to decommissioning categories (inventory dependent activities and waste management). Contingency is calculated based on percentage defined for each item.

Table 1: Results of cost calculation (unit: USD)

Workforce	144,695	Investment	13,423
Total costs	7,798,437	Expenses	1,711,769
Labor cost	4,217,661	Contingency	1,139,179

4. Conclusions

In this paper, the methodology and procedure for decommissioning costing using CERREX software were presented and cost estimation was performed and compared with actual decommissioning cost for KRR-1.

First of all, inventory for KRR-1 was collected and analyzed in the inventory database tool. And a robust cost estimation for decommissioning activities was performed using CERREX software based on ISDC. There are three types of cost estimate that can be used, and each have a different level of accuracy. That is 'Budgetary estimate'; one based on the use of flowsheets, layouts and equipment details, where the scope has been defined, but the detailed engineering has not been performed. The level of accuracy expected is -15 to +30%. The result values of calculated cost were included between -15 to + 30% by type of the 'Budgetary estimate' when compared with actual decommissioning cost. It is made a decision that the CERREX software is useful for preliminary cost estimation.

REFERENCES

[1] IAEA, Cost Estimation for Research Reactor Decommissioning, IAEA Nuclear Energy Series No. NW-T-2.4, 1, No. 2013.
[2] AEN, NEA, International Structure for Decommissioning Costing (ISDC) of Nuclear Installations, 2012.
[3] IAEA, User's manual for costing software for research reactor decommissioning.
[4] Kristofova K., Park S., Zachar M., Daniska V., Application of decommissioning costing for research reactors using CERREX code, International Conference on Advancing Global Implementation of Decommissioning and Environmental Remediation Programmes, 2016.
[5] Vladmir D., International Structure for Decommissioning Costing (ISDC), ISDC Costing methodology, Principles CERREX Costing Software for Research Reactors
[6] IAEA – TECDOC-1476, Financial Aspects of Decommissioning. Report by an expert group. ISBN 92-0-110905-9, ISSN 1011-4289. IAEA Vienna, Nov., 2005