Development of Input Parameters for ALARA Action Level Evaluation of Decommissioning Nuclear Power Plant

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1. Introduction

In the site restoration stage during decommissioning of nuclear power plant, the residual radioactivity in the site must be reduced to less than Derived Concentration Guideline Level (DCGL). However, if the DCGL does not meet the ALARA (As Low As Reasonably Achievable), it is necessary to reduce the residual radioactivity on the site to less that the DCGL. On the other hand, since additional costs may be incurred in the process of reducing the residual radioactivity in the site to less than DCGL, it is necessary to set an appropriate residual radioactivity level to balance cost and benefits through cost-benefit analysis. This level is defined as ALARA action level, and in order to set a action level, an ALARA evaluation based on the ALARA principle is required. Therefore, in this study, we developed an input parameter necessary for the evaluation of ALARA to derive the domestic action level.

2. Materials & Methods

2.1 ALARA Evaluation

U.S. 10 CFR 20 states that in order to terminate a nuclear power plant's operating license, the licensee must demonstrate that the final status meets the radiological criteria for termination and that it meets the requirements for reducing radiation exposure to ALARA. The characteristics of the model used in the ALARA evaluation are as follows:

- The method is simple
- The method is not biased and uses appropriate dose modeling to relate concentrations to dose
- The method is usable as a planning tool for remediation
- As much as possible, the method uses the results of surveys conducted for other purposes

2.2 Cost Calculation

The cost calculation method for ALARA evaluation is as follows[1].

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{PDose} + Cost_{other}$$

Where,
$Cost_R$ = monetary cost of the remediation action
$Cost_{WD}$ = monetary cost for transport and disposal of the waste generated by the action
$Cost_{ACC}$ = monetary cost of worker accidents during the remediation action
$Cost_{TF}$ = monetary cost of traffic fatalities during transporting of the waste
$Cost_{WDose}$ = monetary cost of dose received by workers performing the remediation action and transporting waste to the disposal facility
$Cost_{PDose}$ = monetary cost of the dose to the public from excavation, transport, and disposal of the waste
$Cost_{other}$ = other costs as appropriate for the particular situation

2.3 Benefit Calculation

The benefit calculation method for ALARA evaluation is as follows[1].

$$B_{AD} = V_{AD} \times PW(AD_{collective})$$

Where,
B_{AD} = benefit from an averted dose for a remediation action
V_{AD} = value of averted dose, which is a conversion factor for the monetary value of radiation dose (dollars ($) per person-rem).
$PW(AD_{collective})$ = present worth of a future collective averted dose in person-rem

3. Results

Table 1 Shows the input parameters for calculating costs and benefits. Input parameters such as waste volume, work time, traveled distance are determined according to the characteristics of each nuclear power plant. And input parameters such as waste disposal cost, value of averted dose are the same regardless of the characteristics of the nuclear power plant.

Table 2. Input Parameters of Cost and Benefit

Category	Input Parameter
Cost	• Remediation Volume or Area (m^3 or m^2) • Remediation Speed (m^3/hr or m^2/hr) • Waste Volume (m^3) • Work Time (hr) • Number of Worker (person) • TEDE Rate to Remediation Workers (mSv/hr) • TEDE Rate to Public (mSv/hr) • Waste Shipment Volume (m^3/shipment) • Traveled Distance (km) • Transportation fatal accident rate (km^{-1}) • Value of Incurred Dose ($/person-mSv) • Value of Statistical Life ($) • Workplace Fatality Rate (hr^{-1}) • Labor costs ($/person) • Equipment Rental Fee ($) • Waste Disposal Cost per unit volume ($/$m^3$)
Benefit	• Value of averted dose ($/person-mSv) • Monetary discount (y^{-1}) • Critical Group Population density (person/m^2) • Area of Radiological Environment Impact Assessment (m^2) • Residual Radioactivity after remediation (Bq/g) • Fraction of the residual radioactivity removed by the remediation action (-) • Number of years of exposure (y)

Table 2 shows the input parameters for ALARA evaluation of overseas decommissioning nuclear power plants. In the U.S., values that can be used in common are presented in the NUREG as the number of parameters used for cost-benefit analysis varies. Workplace fatality rate, transportation fatal accident rate, value of averted dose, value of statistical life, Monetary discount, number of years of exposure, and waste shipment volume are not expected to differ between Kori 1 and Wolsong 1. However, population density is likely to vary depending on the surrounding of the nuclear power plant.

Table 2. Input Parameters for ALARA evaluation of overseas decommissioning nuclear power plants [1][2][3]

Input Parameter	Value
Workplace Fatality Rate	1.8×10^{-8}/h
Transportation fatal accident rate	1.85×10^{-9}/km
Value of averted dose, Value of Statistical Life	$5,200/person-rem
Monetary discount	0.03 y^{-1}, 0.07 y^{-1}
Number of years of exposure	Building: 70y Soil: 1,000y
Population density	Building: 0.09person/m^2 Land: 0.0004person/m^2
Waste shipment volume	13.6 m^3/shipment

4. Conclusions

In this study, we developed an input parameter necessary for the evaluation of ALARA to derive the domestic action level. ALARA evaluation is required to determine whether DCGL satisfies ALARA, and ALARA evaluation is performed through cost-benefit analysis. Remediation volume, waste volume, work time, etc., are required for cost calculation, monetary discount, population density, etc., are required for benefit calculation. In the U.S., it was found that common values were provided for various factors. The results of this study are expected to be used as basic data for ALARA evaluation in Korea.

REFERENCES

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