Risk Assessment Method for the Decommissioning Activities by Using Risk Matrix

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1. Introduction

One of the important parts of NPP (Nuclear Power Plant) decommissioning preparation is to secure the safety associated with planned activities. Various approaches have been used to evaluate safety for NPP decommissioning. Methodologies such as HAZOP (HAZard and OPerability analysis) for identification of possible deviations form planned activities, or risk matrix for risk rating have been used for a safety evaluation. In particular, in using the risk matrix, setting the levels such as radiation exposure, consequences, and likelihood for each axis will be a crucial factor to be resolved. Therefore, in this study, we introduce a risk rating methodology using the risk matrix for decommissioning activities.

2. Methods

2.1 The main steps of safety assessment

In the safety assessment, relevant items to be performed at the initial stages are the characterization of the site and systems to be decommissioned. The use and handling of nuclear fuels are known as the main content of the safety assessment during the operation of NPP, while the radioactivity and systems, structure, and components (SCCs) are the main subject during the decommissioning. In summary, the safety assessment of a NPP identifies potential events in decommissioning activities and, therefore, assesses its impact during normal decommissioning or in the event of an accident. It is a series of processes that compares the evaluation results with the safety standards and implements controls to safely manage risks that do not meet the criteria. The main steps of safety assessment can be listed [1]: (1) safety assessment framework; (2) description of the facility and decommissioning activities; (3) hazard identification and screening; (4) hazard analysis; (5) engineering analysis; (6) evaluation of results and identification of safety control measures; (7) independent review by the operator and/or regulator prior to implementation of the controls in practice.

2.2 Risk matrix for risk assessment

As a methodology for assessing safety, risk matrix has been used to rank various risks in order of importance. The risk matrix consists of the elements of two axes; in order to determine the rankings, the risk is determined by multiplying the values of two elements of the axis by the level values. The risk matrix shown in Fig. 1 would be an example.

Consequence	Injury	Level of likelihood				
		1	2	3	4	5
		< 10%	10% ~ 25%	25% ~ 50%	50% ~ 75%	> 75%
5	> 1 yr or death	5	10	15	20	25
4	3 mon ~ 1 yr	4	8	12	16	20
3	1 mon ~ 3 mon	3	6	9	12	15
2	1 week ~ 1 mon	2	4	6	8	10
1	No injuries	1	2	3	4	5

Fig. 1. Example of risk matrix.

The safety assessment of the decommissioning activities is largely divided into works associated with radiological hazards and non-radiological hazards. The likelihood will be used as input values as one axis for both radiological hazards and non-radiological hazards, and the other axis will be the radiation exposure and the consequence.

2.3 The levels of consequences and likelihood

In general, the risk matrix may be a 3 × 3 cells, 5 × 5 cells, 5 × 7 cells, or more cells matrix depending on the levels of radiation exposure, consequences, and likelihood as elements of axes. And the frequency and severity of accidents are determined by scaling down or raising the levels depending on the scale of activities and processes being evaluated [2]. Therefore, in applying the risk matrix for decommissioning NPPs, appropriate application shall be made to the levels of risk consequence and likelihood.

3. Results & discussion

3.1 The Level of consequence

Table 1 demonstrates the severity of consequences for the activities to assess the radiological and non-radiological risks associated with the decommissioning work.

Table 1. Levels of consequence

Level	Description	Radiation Dose [3]	Injury or Disease [3]
1	Insignificant	< 0.1 mSv	No injuries
2	Minor	0.1-1 mSv	1 week-1 mon
3	Moderate	1-20 mSv	1-3mon
4	Major	20-100 mSv	3mon-1yr
5	Severe	>100 mSv	>1yr or one death

3.2 The Frequency evaluation table

The frequency of occurrence is usually determined by taking into account recent industrial accidents, disasters, and anticipated risks in a similar situation. Therefore, in this study, the frequency is assumed consisting of 5 levels as shown in Table 2.

Table 2. Frequency evaluation table

Level	Description	Decision Criterion
1	None	- Not expected to occur. - Less than 1 occurrence in 5 years.
2	Attention	- Very unlikely. - Less than 2 occurrences in 5 years or 2~3 in a similar situation.
3	Caution	- Unlikely. - Less than 3 occurrences in 5 years or 4~5 in a similar situation.
4	Warning	- Likely. - Less than 5 occurrences in 5 years or 6~7 in a similar situation.
5	Danger	- Very likely. - More than 5 occurrences in 5 years or more than 7 in a similar situation.

3.3 Risk evaluation

The risk of decommissioning activities can be ranked in accordance with the classified consequences and frequency, and the risk assessment table can be depicted as Fig. 2 based on proposed levels of radiation dose, injury, and likelihood. Depending on the risk rating, the red area will not be allowed to work, and it will be possible to classify activities requiring a stepwise conditional acceptance or management measures.

Consequence	Radiation Dose	Injury or Disease	Level of likelihood				
			1	2	3	4	5
			None	Attention	Caution	Warning	Danger
5	> 100 mSv	> 1 yr or death	5	10	15	20	25
4	20 - 100 mSv	3 mon ~ 1 yr	4	8	12	16	20
3	1 - 20 mSv	1 mon ~ 3 mon	3	6	9	12	15
2	0.1 - 1 mSv	1 week ~ 1 mon	2	4	6	8	10
1	< 0.1 mSv	No injuries	1	2	3	4	5

Fig. 2. Risk evaluation table.

4. Conclusion

In this paper, we reviewed the level of consequences and likelihood that should be established to determine the activities in order of importance for the safety assessment of NPP decommissioning. Each level can be defined in terms of the nature and scale of the work, and we set the criteria by referring to the existing risk assessment method for the general industry and materials related to safety management in NPP operation. The classified detailed level of the risk matrix of this study can be more expanded in the future to enhance the reliability of the safety assessment and to be used as a reference for evaluation of the safety of NPP decommissioning.

REFERENCES

[1] IAEA, Safety Assessment for Decommissioning, International Atomic Energy Agency Safety Reports Series No. 77, 2013.

[2] KOSHA, Guidelines for risk assessment of machinery and equipment manufacturing, Korea Occupational Safety and Health Agency, G-84-2012, 2012.

[3] Kwan-Seong Jeong, Kune-Woo Lee, Hyeon-Kyo Lim, Risk Assessment on hazards for decommissioning safety of a nuclear facility, Annals of Nuclear Energy, 2010.