Quantitative Risk Analysis for Decommissioning Safety Assessment of Nuclear Facilities

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1. Introduction

The radiological and non-radiological hazards arise during decommissioning activities. The non-radiological or industrial hazards to which workers are subjected during the decommissioning and dismantling process may be greater than those experienced during the operational lifetime of the facility. The hazards associated with decommissioning are important not only because they may be a direct cause of harm to workers but also because their occurrence may, indirectly, result in increased radiological hazard. Workers need to be protected by eliminating or reducing the radiological and non-radiological hazards that may arise during routine decommissioning activities and as well as during accidents[1][2]. Hazard identification should begin by identifying all potential radiological and non-radiological hazards which harm could be realized. A radiological hazard is a worker exposure. And non-radiological hazards include industrial safety practices such as fire, explosions, falling, collision, etc closer to construction safety than operational safety[3].

2. Quantitative risk assessment of decommissioning activities

An approach to quantitative risk assessment consists of tow ways. Risk assessment approach to a radiological hazard is results of exposure assessment within work scenario and pathway. And risk assessment approach to a non-radiological hazard is quantitative risk ranking by using a risk matrix. The risk matrix is determined by the consequences and likelihood.

2.1 Risk assessment of a radiological hazard

A radiological risk matrix uses the detailed level of worker exposure. The detailed level of worker exposure are classified by making reference to the radiation safety management manual of nuclear power plant operations, the decommissioning project of KRR-2 and UCF in Korea and ICRP.
Overall radiological risks can be lower during decommissioning than during operation. The nature of decommissioning activities can mean that there is an enhanced risk of exposure for some workers. Remote handling and robotics technologies can greatly mitigate these risks, but when these are un available, worker exposure must be carefully managed. The established dose limits must be fulfilled and applicable dose constraints should restrict the projected individual doses.

Consequence Level of Exposure (Unit:mSv)	
R7	< 0.1
R6	0.1 ~ 0.5
R5	0.5 ~ 2
R4	2 ~ 20
R3	20 ~ 50
R2	50 ~ 250
R1	250 ~

Figure 1. Levels of worker exposure

2.2 Risk assessment of a non-radiological hazard

A non-radiological risk matrix consists of consequences' level and likelihood's level of a non-radiological hazard.

Level	Injury Period
1	No Injury
2	1 week ~ 1 month
3	1 month ~ 3 month
4	3 month ~ 1 year
5	> 1year or one death

Level	Description
1	< 10%
2	< 25%
3	25% ~ 50%
4	50% ~ 75%
5	> 75%

Figure 2. Levels of consequence and likelihood

Levels of Consequence	
1	No Injury
2	1 week ~ 1 month
3	1 month ~ 3 month
4	3 month ~ 1 year
5	> 1year or one death

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Levels of likelihood	
1	< 10%
2	< 25%
3	25% ~ 50%
4	50% ~ 75%
5	> 75%

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Likelihood \ Consequence	1	2	3	4	5
5	N10	N8	N4	N2	N1
4	N10	N8	N5	N3	N2
3	N10	N9	N7	N5	N4
2	N10	N9	N9	N8	N6
1	N10	N10	N10	N10	N10

Figure 3. Risk calculation of a non-radiological hazard

Risk calculation can be performed by consequences and likelihood. Risk of the non-radiological hazard calculation is assessed as follows.

·N1~N3 : Stop accomplishing a decommissioning work activity and after elimination and reduction of hazard accomplish one.

·N4~N9 : Accomplish a decommissioning work activity under actions and control

·N10 : Accomplish a decommissioning work activity as it is

3. Risk ranking method of combining the radiological risk and the non-radiological risk

In case that both radiological hazard and non-radiological hazard exist, using risk priority number (RPN), by comparing the risk of scenarios and works, the precedence of risk reduction is determined.

In case that only non-radiological hazard exists, by comparing the risk of scenarios and works and comparing each maximum value of a non-radiological risk ranking score (risk matrix), the precedence of risk reduction are determined.

Hazard Class	Results of Risk Matrix	RPN
Radiological	R1	1
	R2	2
	R3	3
	R4	4
Non-radiological	N1	5
	N2	6
	N3	7
Radiological	R5	8
Radiological	R6	9
Non-radiological	N4	10
	N5	11
	N6	12
	N7	13
	N8	14
Radiological	R7	15
Non-radiological	N9, N10	16

Figure 4. Risk priority number of the radiological and non-radiological risk

REFERENCES

[1] IAEA, "Standard Format and Content for Safety related Decommissioning documents", Safety Reports Series No. 45, (2005)

[2] OECD/NEA, "Achieving the Goals of the Decommissioning Safety Case", (2005)

[3] U.S. DOE, "Statistical Evaluation of DOE D&D Occurrences", DOE/EH-0578