Establishment of Risk-based Accident Scenarios and Exposure Dose Modeling Related to LILW Management in the Temporary Storage Facility

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1. Introduction

Up to present, much of the LILW has being managed in terms of the surface dose and waste stream. However, most of radioactive wastes including the LILW will be managed in terms of the risk-based approach to future regulation system. If the radioactive wastes do not quantitatively deal with the risk-based regulation, the radiological risk on some of radioactive wastes might be overestimated or underestimated regardless of the degree of the risk.

The main objective of this study is to develop influence factors such as the initiating event when conducting the risk assessment on the temporary storage facility of LILW, and to establish the arbitrary accident scenarios that may occur when managing the LILW in the temporary storage facility. According to the definition of the risk, which is the probability of occurrence of an undesired event multiplied by the consequences of the event, the result of this study can be referred to establish the arbitrary accident scenarios when the risk assessment for workers and public with regard to the temporary storage facility of LILW is conducted [1].

2. Development of Risk-based Accident Scenarios

2-1. Event tree analysis

The risk-based accident scenarios developed in this study were derived through the ETA method which is used by the accident sequence analysis of PSA on NPP. The ETA is logical process making up the accident sequence by the binary tree in accordance with the success or failure of selected initiating events [2]. On the event tree, an upward branch indicates success and a downward branch indicates failure. The pathways through the event tree are then drawn.

The ETA is conducted within a part of the accident sequence analysis for understanding accident sequences resulting from the release of radioactive materials. In general, the initiating event analysis and event tree analysis are included in the category of an accident sequence analysis, and then all of analysis works are not independently, but interdependently conducted.

2-2. Risk-based accident scenarios concerned with LILW management in the temporary storage facility

Based on two main initiating events, four heading events for establishment of risk-based accident scenarios were derived in Table 1: lifting failure, worker's error, gas generation, and fire.

Table 1. List of the initiating events used in the event tree analysis

Drop		**Fire**	
Lifting failure	**Worker's error**	**Gas generation**	**Fire**
- Tipping over due to errors caused by an skilled workman - Dropping due to stacking too many drums on the vehicle - Lifting failure due to the mechanical defects		- Gas generation due to the dropping of drums and collision with some objects - Gas generation by the long-term storage of drums	- Fire initiated within the transport vehicle - Fire due to the presence of combustive materials

The 12 risk-based accident scenarios were developed by the ETA method based on the binary tree. However, two of these scenarios were excluded because there was no risk factor. The main cause of ten accident sequences derived can be also divided with two kinds of reason, which are the release of radioactive materials and the existence of combustible materials.

3. Methodology on Exposure Dose Evaluation Modeling

The main initiating events led to the arbitrary operational accident, which is the dropping of a drum and fire, were derived from MLD method. The exposure effects resulted from release of radioactive materials related to arbitrary accident in the temporary storage facility for LILW can be divided with the external exposure by radioactive lump and internal exposure caused by breathing. The equation (1) for the external exposure dose by radioactive lump consisted of following parameters: dose conversion factor in respect of each radionuclide, atmospheric relative concentration (χ/Q), the release amount of each radionuclide, and constant. And then, the equation (2) for the internal exposure dose by breathing was also constituted by similar contents used in the equation (1), except for considering the breathing rate (m^3/sec).

$$DP = \sum_i \left(\frac{1}{3600}\right)\left(\frac{\chi}{Q}\right)_i f\, Q_i DFP_i \quad \cdots\cdots (1)$$

$$DH = \sum_i \left(\frac{\chi}{Q}\right)_i f\, Q_i Br_i DFH_i \quad \cdots\cdots (2)$$

The 13 radionuclides and gross α were considered for the source term with respect to the internal and external exposure dose evaluation: ^{3}H, ^{14}C, ^{55}Fe, ^{58}Co, ^{60}Co, ^{59}Ni, ^{63}Ni, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, ^{144}Ce, and Gross α. Furthermore, according to the U.S.NRC regulatory guide 1.145, the atmospheric relative concentrations (χ/Q) were derived by meteorological data measured in NPP site: wind speed, wind direction, and a measure of atmospheric stability. For the evaluation of internal exposure, the breathing rate (m^3/sec) described in U.S.NRC regulatory guide 1.8 was considered.

4. Conclusion

The initiating event analysis was used to identify the full spectrum of potential risk related to LILW management in the temporary storage facility. Furthermore, the initiating events needed for the risk-based accident scenarios were deductively derived by the MLD method based on the FTA. Then, the risk-based accident scenarios were developed by the ETA method through the derived initiating events.

Consequently, based on the two main initiating events, four heading events constituted with the lifting failure, worker's error, gas generation and fire were derived, and then the 12 risk-based accident scenarios concerning the LILW management in the temporary storage facility were finally established by the ETA method based on the binary tree.

And then, the internal exposure dose by breathing can be derived by the combination with the following elements: the atmospheric relative concentrations, release amounts of each radionuclide due to the arbitrary accident in temporary storage facility, breathing rate and dose conversion factor on the internal exposure. Similarly, the exposure dose by radioactive lump can also be calculated by the contents considered in the internal exposure dose evaluation except for the element of the breathing rate.

References

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