A Methodology of Safety Assessment during Operation of Radioactive Waste Repository

Eun Yong Lee, Jeong Hyoun Yoon, Min Su Ju and Chang Lak Kim
Nuclear Engineering & Technology Institute, Korea Hydro & Nuclear Power Co. Ltd.
Jang Dong 25-1, Yuseong, Daejeon, Korea 305-343,
E-mail : jhyoon@khnp.co.kr

1. Introduction

As the site of repository was materialized, a number of licensing activities for the construction and operation are being pursued including safety assessment of transportation of radioactive material. This paper introduces a methodology to assess potential exposures to individuals due to accidents or unusual conditions during handling, storage, and disposal of waste. The analyses provide reasonable assurance that potential exposures to individual members of the public will be within the requirements in atomic energy act or other radiological guidelines.

2. Regulatory Guidelines

The dose limits given in regulations are associated with occupational doses incurred during routine operations and are not applicable to accidents in radioactive waste repository. It is also noted that the 1 mSv dose limit described in the atomic energy acts is the total dose that an individual member of the public could receive from short-term liquid or gaseous effluent releases or from direct radiation from the site due to normal operations. Table 1 shows that dose constraints defined as performance objective of operational accident in GyungJu repository.

Table 1. Performance Objects applied for Operational Accident in Repository

	Performance object	Regulations
normal condition	- worker : 20mSv/yr - public : 0.1mSv/yr [at site boundary]	- Enforcement of Nuclear law - Notification 2002-23[Radiation protection] 16,2,1 - Nuclear power plant 25rem(public)
accident	- worker : 50mSv - public : 5.0mSv	

3. Accident Scenarios

Operations will be performed in a manner consistent with industry standards to ensure the accident related risk to workers and members of the public is minimized. Risk includes consideration of both the frequency of occurrence of a given accident scenario, and the potential human health-related consequences of the given accident scenario. Hence, accidents with a relatively high likelihood of occurrence but relatively small consequences are evaluated, as well as accidents with a relatively small likelihood of occurrence but potentially large consequences. After reviewing relevant design and operations-related information, the following set of accidents was developed. This set is considered to portray a proper and sufficiently comprehensive radiological accident-related risk profile for the proposed waste disposal facilities.

- Fire – Waste Handling Building, Disposal Facility, Vehicle
- Drop – Waste Handling Building, Earthquake, Silo
- Crane malfunction suspends high radiation package for extended period of time(this depends on characteristics of the facility)
- Miscellaneous – Electric short, lighting, Strong Winds,

For accident conditions involving the release of airborne radionuclides, inhalation doses are usually dominated. External radiation doses from immersion in the airborne plume are generally orders of magnitude lower than the inhalation doses. This is illustrated by the comparison of inhalation and immersion dose conversion factors. Dose conversion factors usually were taken from guidelines based on ICRP60. The common radionuclides in LLRW are representative of alpha, beta, and gamma emitters and the conclusions based in these radionuclides are also true for other radionuclides. Overall process for accident assessment in repositories employed by DOE is represented by Figure 1. Typical scenarios considered for safety assessment of accident in operation is summarized in Table 2

The relative importance of external doses compared to inhalation doses is illustrated by taking the ratio of external to inhalation doses for a representative sample of radionuclides. The inhalation dose (in sieverts) for a radionuclide is:

$$Inhalation\ Dose = CON \times BR \times T \times DCFInh \quad (1)$$

where ;

CON = Airborne concentration (Bq/m^3)
BR = Worker breathing rate (2.57E-04 m^3/s)
T = Time exposed to airborne plume (s)
DCF_{inh} = Inhalation dose conversion factor (Sv/Bq)

The external received while immersed in the airborne plume is given by:

$$External\ Dose = CON \times T \times DCF_{Ext} \quad (2)$$

where ;
CON = Airborne concentration (Bq/m^3)
T = Time exposed to airborne plume or contaminated object(s)
DCF_{Ext} = External immersion dose conversion factor (Sv/s per Bq/m^3) The ratio of the external immersion dose to the inhalation dose can be expressed by the dose ratio,

DR, defined as:

DR = External dose / Inhalation dose (3) or

$$DR = DCF_{Ext} / (BR \times DCF_{inh}) \quad (4)$$

For most radionuclides, the external dose is several orders of magnitude less than the inhalation dose. As expected, the most significant external doses come from the gamma emitters Co-60 and Cs-137. This implies that the worker doses from external radiation in an airborne plume are almost negligible

For all accident consequence assessments that involve the uncontrolled release of radionuclides to the atmosphere, the radioactivity concentrations to be associated with a given portion of damaged waste.

However, the waste forms and nature of contamination can result in much smaller airborne release fractions (ARF) under accident conditions than the ARF associated with the wastes. More specifically, actinides are nearly always the dominant contributors to the total dose received via the inhalation pathway. The waste form and nature of contamination impact the ARF under accident conditions by much more than a factor of 10.

Table 2. Typical Scenarios Considered for Safety Assessment of Accident in Operation [1]

Considered Scenario	Exposure Receptor	Exposure pathway
Waste container drops from crane scenario	Site boundary	Direct and Inhalation
Dropped cover block	Bound by waste container drop	
Crane malfunction scenario	Bound by waste container drop	
Forkkifit/stacker accident scenario	Bound by waste container drop	
Transport damage scenario	Bound by waste container drop	
Fire in transport vehicle scenario	Site boundary truck area	Direct and Inhalation
Fire in a disposal cell scenario	Bound by transport vehicle fire	
Natural event scenario[like tornado]	Location of container	Direct and Inhalation
Criticality scenario	None, not credible	

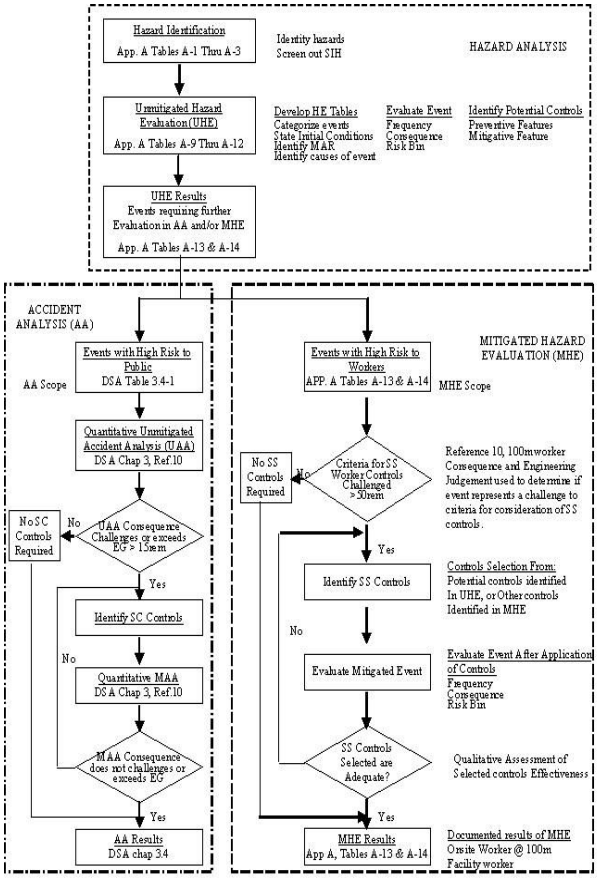

Figure 1. Procedure of Safety Assessment of Accident in Operation [2]

4. Conclusion

A methodology for the operational safety assessment of radioactive waste repository is introduced and described. The methodology should be justified before it is used as safety analysis. Many of scenarios described can be easily derived from other industrial accident such as fire or dropping heavy objects. Therefore, much effort to justify the scenarios and its parameters for the safety assessment should be made.

REFERENCES

[1] Central Interstate Compact Butte, Nebraska, Low-level Radioactive Waste Disposal Facility Safety Analysis Report.
[2] Application for License to Authorize Near-Surface Land Disposal of Low-Level Radioactive Waste, 2004