Review on the Foreign Uncertainty Management Programs on the Safety Case for a HLW Repository

Jongtae Jeong*, Dong-Keun Cho, and Min Hoon Baik

Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea

*jtjeong@kaeri.re.kr

1. Introduction

Recently, many countries are implementing a repository development program for the disposal of high level wastes including spent fuels. And they are developing a safety case based on the long-term safety assessment for the smooth implementation of a repository development program. However, the safety assessment results of a HLW repository are subject to uncertainty, and the management of uncertainties is recognized as an important element of a safety case. In this paper, we review an uncertainty management program of several countries and identify the challenges related to the uncertainty management for the safety case.

2. Review of uncertainty management programs

2.1 Sweden

SKB performed a study on the repository layout accounting for uncertainty concerning the location and size of fractures [1]. According to the safety analysis of a repository, they found that a canister may fail if subjected to a sufficiently large shear movement due to earthquakes. However, such failure can be avoided by avoiding canister deposition in or close to fracture zones and in positions where intersection with a large single fracture is indicated. By conditioning these rules, the calculated risk contribution associated with earthquakes is greatly reduced. There are, however, large uncertainties with the network of single fractures between major zones. In order to find the fracture sizes to be avoided, they performed a study by simulating detailed process models, and found that it depends on the magnitude of earthquake, distance to earthquake-generating fault, size, and position and orientation of target fracture. And they estimated the fracture size to be avoided as a function of distance to potential earthquake-generating fault.

2.2 Finland

According to the regulatory guidelines in Finland, the uncertainties included in the safety analysis shall be assessed by means of appropriate methods, e.g., sensitivity analysis or probabilistic methods. Therefore, POSIVA has developed a systematic approach (Fig. 1) for the management of uncertainties in the safety case based on iterative process [2]. The overall strategies for uncertainty management are: identify, avoid, reduce, and assess. Uncertainties have to be described and quantified, and their relevance to safety needs to be considered. They recognized that uncertainties can be reduced by gaining new knowledge and understanding of the system behavior through appropriate researches. Some uncertainties will always remain and have to be assessed in terms of their relevance to the final conclusions on safety.

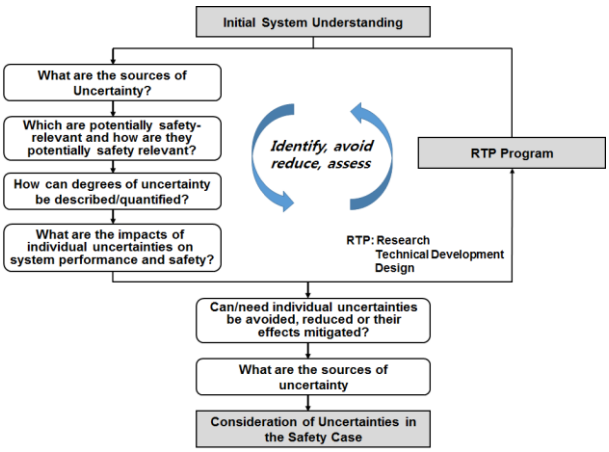

Fig. 1. POSIVA's iterative approach to the management of uncertainties [2].

2.3 USA

The USNRC emphasized the importance of an appropriate assessment of the uncertainty in performance assessment (PA) for both WIPP and YM repositories. In the conceptual and computational structure of 2008 YM PA, three uncertainties are considered: the uncertainty in the occurrence of future events; models for predicting the physical behavior and evolution of the repository system; and the uncertainty associated with analysis inputs. They recognized the uncertainty and sensitivity analysis as an important role in the development of potential solutions for radioactive

waste disposal. In addition, they developed several kinds of methods for uncertainty and sensitivity analysis and applied them to the PA of WIPP and YM repositories. The typical representation of uncertainty analysis results included in the safety assessment of the YMP [3] is shown in Fig. 2.

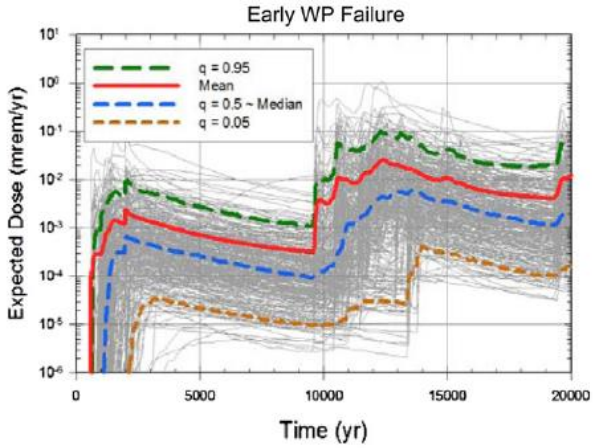

Fig. 2. Typical representation of uncertainty analysis results of YMP [2].

2.4 France

ANDRA developed a qualitative safety analysis (QSA) to examine the uncertainties regarding: the characteristics of each component; its evolution over time; and its interactions with other components. The QSA can be used to explore possible dysfunctions of the repository components, to propose design measures, and to identify scenarios to be quantified. Examples of uncertainty management using QSA are as follows: analysis of the primary vitrified waste package; analysis of the over-container for vitrified waste packages; analysis of galleries seals; and analysis of the host rock.

2.5 Belgium

Belgium has been developing and using tools for uncertainty management to steer the RD&D of a geological disposal program. They are developing and implementing a long-term management system for a repository by considering uncertainties. For parameter uncertainty, they considered parameter uncertainty expressed using PDF and uncertainty factor. However, they acknowledged that the use of PDF irrespective of their aleatory or epistemic characteristics may be ill-defined and mislead the characterization of the uncertainty. Therefore, they considered the expert management by asking experts to estimate two ranges of parameter value: expert range and source range. Finally, they put more emphasis on the identification of the uncertainty associated with the parameter than on the search of a single best estimate value.

2.6 England (UK)

In the UK, the regulatory body insist that the developer of a repository should: 1) establish and maintain a register of significant uncertainties; 2) develop clear strategies for managing uncertainties; 3) assess whether uncertainties can be reliably quantified. NDA uses two approaches (bottom-up and top-down) to develop a model hierarchy (process-component-total system models) from two different viewpoints. They insisted modeling is recognized as having several roles, for example, to aid process and system understanding, inform R&D and optimization, in addition to calculating risks; and it has found its appropriate place in safety case development and presentation.

3. Conclusion

Appropriate strategies for uncertainty management have to be established and an efficient communication skill for uncertainty to the public is necessary for the implementation of a repository development program successfully. The challenges to be resolved related to the management of uncertainty are as follows: 1) how to determine which uncertainties are matter; 2) how to make decisions when there are significant uncertainties; 3) how to demonstrate confidence in the safety case when there are still uncertainties; 4) how to regulate in the face of uncertainty; 5) how to communicate uncertainties to the public.

Acknowledgements

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