A Safety Case of the Conceptual Disposal System for Pyro-processing High-level Waste Based on the KURT Site (AKRS-16)

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1. Introduction

A safety case in the disposal of radioactive waste is necessary to improve the confidence of disposal safety, develop a disposal program, and obtain a proper license for a radioactive waste disposal facility. A safety case also needs to be developed iteratively and improved during all development stages of a disposal program such as the concept development, site selection, construction and operation, and closure stages. KAERI (Korea Atomic Energy Research Institute) has developed a geological disposal system (A-KRS) and a safety case for the geological disposal of all kinds of radioactive wastes generated by the recycling (pyro-processing and sodium fast reactor) of spent fuel from PWR (pressurized water reactor) nuclear power plants in Korea. Recently KAERI published a safety case report (AKRS-16) in order to develop and establish a disposal concept for the geological disposal of high-level waste (HLW) from pyro-processing based on the KURT (KAERI Underground Research Tunnel) site. In this study, the safety case report (AKRS-16) will be introduced and the strategy, contents, and applicability of the safety case report are discussed.

2. Methods and Results

2.1 Strategy for Safety Case Development

The safety case is defined as an integration of arguments and evidence that describe, quantify and substantiate the long-term safety, and the associated level of confidence, of the geological disposal facility [1]. In Korea, the safety case is considered and mentioned in 'Confidence Building' part of the NSSC Notice 'General Guideline for Deep Geological Disposal Facility of High-Level Radioactive Wastes' as "Decision on the agreement of the safety assessment results with safety goal should be supported by multiple arguments such as analysis of probabilistic distribution of dose and risk, uncertainty analysis of the assessment, comparative evaluation using natural analogues and complementary safety indicators, and ensuring evidences for defense-in-depth" [2].

The roles of the safety case in the radioactive waste disposal can be summarized as:

- integration of relevant information in a structured, traceable and transparent way that demonstrates an understanding of the behavior and performance of the disposal system in the period after closure,
- identification of uncertainties in the behavior and performance of the disposal system, analysis of the significance of the uncertainties, and identification of approaches for the management of significant uncertainties,
- demonstration of long-term safety by providing reasonable assurance that the disposal facility will perform in a manner that protects human health and the environment,
- support for decision making in the development of a disposal facility in the step by step approach, and
- facilitation of communication between stakeholders on issues relating to a disposal facility.

We have developed a safety case and the disposal system (A-KRS) for the deep geological disposal of radioactive wastes generated by the pyro-processing of PWR spent fuel. In order to develop the safety case, following works were sequentially carried out:

① establishment of a basic plan and implementing strategy for the safety case development through a cooperation with an foreign special company (Saanio & Riekkoll, Finland),
② construction of a portfolio including major necessary tasks for the safety case development,
③ decision of contents of the safety case report by analyzing the structure of the safety case,
④ organization of a task force team for writing the safety case report,
⑤ review of the report by an foreign and domestic experts and by holding a workshop,
⑥ revision of the safety case report considering the review results, and
⑦ publication and distribution of the safety case report.

Fig. 1 shows the portfolio and contents of the AKRS-16 safety case report. Fig. 2 shows the published safety case report AKRS-16.

Chapter	Contents
Chapter 0	Executive Summary
Chapter I	Design Base & Disposal Facility
Chapter II	Site Description
Chapter III	Waste
Chapter IV	Engineered Barrier System
Chapter V	Features, Events and Processes & Scenarios
Chapter VI	Model and Data
Chapter VII	Safety Assessment
Chapter VIII	Complementary Considerations
Chapter IX	Safety Case Synthesis

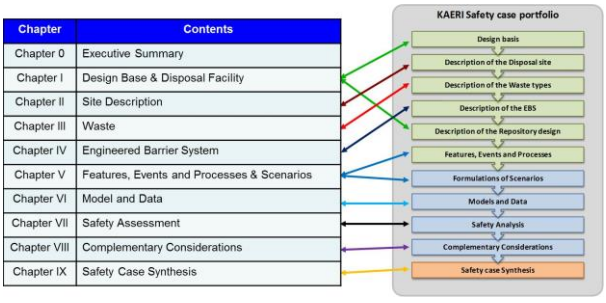

Fig. 1. The contents and portfolio of the safety case report (AKRS-16).

Fig. 2. The safety case report (AKRS-16) published.

2.2 Contents of the Safety Case Report

The safety case report consists of one synthesis report and eight portfolio reports and the major contents of the reports are as follows:

- Synthesis Report: introduction, background, context, and summary of the safety case report, respectively
- Report I. Design Base & Disposal Facility: regulatory requirements, design methodology, disposal system, disposal facility, and description of KURT
- Report II. Site Description: investigation methodology, surface environment, geology of bedrock, hydrogeology, hydrogeochemistry, nuclide transport, and underground spacing problem based on the KURT site
- Report III. Description of Waste Type and Characteristics: current status of spent fuels in Korea, type and characteristics of pyro-processing waste, and inventory of nuclides in the waste including decay heat and radioactivity
- Report IV. Engineered Barrier System (EBS): characteristics of the EBS components such as canister, buffer, and backfill and plug, and thermal and mechanical stability of the components
- Report V. Features, Events, Processes (FEPs) and Scenarios: development of FEPs and construction of scenarios including reference, alternative (well intrusion and earthquake), and complex scenarios
- Report VI. Models and Data: models and data structure system (AMF: Assessment Model Flowchart), system evolution models such as, inventory, canister corrosion, EBS THM (Thermo-Hydraulic-Mechanical) behavior, hydrology in fractures, groundwater chemistry, and potential pathways of nuclide, and nuclide release models and data such as dissolution, sorption, diffusion, and effects of microbe and colloids, etc.
- Report VII. Post-Closure Safety Assessment: safety assessment methodology including regulatory requirements, models and data, and K-PAM (KAERI Performance Assessment Model) as a TSPA (Total System Performance Assessment) tool, and safety assessment procedure and results for reference, alternative, and complex scenarios with uncertainty analysis
- Report VIII. Complementary Considerations: supplementary considerations for the safety case such as radiological hazard by spent fuel, strength of geological disposal, A-KRS design and safety concept, suitability of KURT site, complementary safety indicators, and natural analogues

2.3 Application of the Safety Case Report

Our safety case report AKRS-16 shows interrelationship among the safety case portfolio reports as well as their comprehensive descriptions. This report provides necessary RD&D (Research, Development, and Demonstration) plans for updating the safety case at each step of a disposal program. Thus, this safety case report can be applied in the following areas:

- provision of technical data and information necessary for feasibility confirmation of the geological disposal of all wastes generated from the recycling process of spent fuels including pyro-processing which is being developed in Korea,
- provision of RD&D plans and technical data (including RD&D results from development of high-level waste disposal based on the KURT site) for safety assessment and confidence building in the HLW disposal in Korea to be performed in the future,
- application to developing regulation technologies and guidelines for the geological disposal of HLW in Korea, and
- contribution to confidence building in communication with the public for the geological disposal of HLW.

The confidence of the safety for HLW disposal can be improved through the safety case development in terms of following aspects [3]:

- construction of a reliable information database,
- understanding of processes related to safety,
- reduction of uncertainties in safety assessment,
- communication with stakeholders, and
- ensuring justice and transparency.

3. Conclusions

The development of the safety case is an essential and the most important element of the long-term management of radioactive wastes. The development of the safety case evolves as a repository development program continues to advance. In most countries, the development of the safety case focuses on the post-closure stage. However, the concern of development of the safety case during the operation stage is increasing recently. Therefore, the development of the safety case

at each stage (site characterization and selection, construction and operation, post-closure) of a repository development program is necessary. The cooperation between the regulatory body, implementer, and research institutes as well as international cooperation is strongly recommended for the development of the safety case. RD&D programs for supporting the safety assessment at each stage of a repository development program are necessary because the safety assessment is the fundamental element of a safety case. Our safety case report entitled "A Safety Case of the Conceptual Disposal System for Pyro-processing High-Level Waste Based on the KURT Site (AKRS-16)" will provide useful information for the various stakeholders such as government, implementer, regulator, related experts, and the public peoples. Thus we need to continue to develop and update the safety case for the successful progress of a national radioactive waste management program.

REFERENCES

[1] OECD/NEA, Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste, OECD/NEA, Paris, 2012.
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[3] M. H. Baik, Nak-Youl Ko, Jongtae Jeong, Kyung-Su Kim, Confidence Improvement of Disposal Safety by Development of a Safety Case for High-Level Radioactive Waste Disposal, Journal of Nuclear Fuel Cycle and Waste Technology, Vol.14, p.367, 2016.