Safety Considerations for Optimal Development of National LILW Repository Complex

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1. Introduction

Gyeongju repository is the national radioactive waste management center where all the domestic LILW is to be disposed of throughout this century. The repository has been developing underground silos (2006~) and near-surface vaults (2012~), and it is now setting about landfill disposal. In such a complex development, diverse steps or situations will proceed concurrently for different disposal facilities. This paper considers some safety points for overall development of the unique repository complex.

2. Step-by-step safety case approach

A disposal system and the relevant safety case should be optimized step by step based on the previous experience, the latest data and best available techniques, and updated contents of the next steps [1]. Such a point should be emphasized for the repository complex. Fig. 1 shows a range of steps and important elements to be reflected at each step for this purpose.

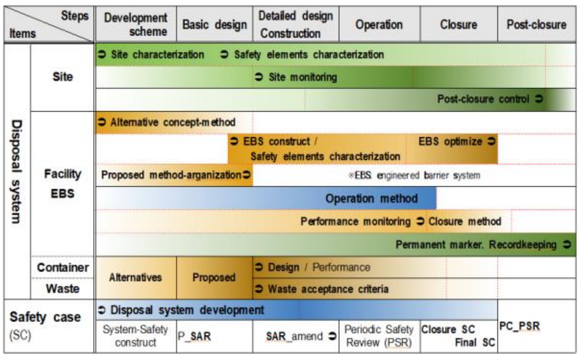

Fig. 1. Overall considerations for repository development.

For example, all the steps and components should be considered for new development, and operational safety and the succeeding processes should be considered for the underground facility in operation.

The repository complex should be developed based on an appropriate safety case to the situation with an overall sketch of the development. The safety case should be constructed progressively even till post-closure phase, which is also important for future introduction of similar hazardous applications [2,3].

3. Systems analysis for overall optimization

Improper processes of development, including incongruity between disposal demand and repository provision, may have a significant impact on the predisposal management as well as on the disposal safety. Therefore, a due arrangement is needed between the overall schedule and the steps implementation. In this sense, relevant regulatory activity should also include a review, in terms of radiological safety, on the overall development program with connection to predisposal management.

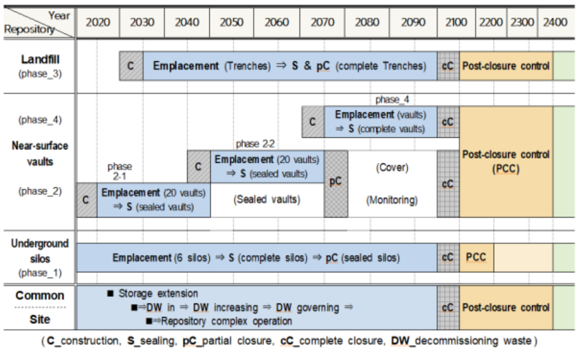

Fig. 2. An overall development plan for the complex.

Fig. 2 is an example of the overall development, which reconstructs one of the recent drafts by the developer. Such a schema may bring an overview of the whole development. Again, the safety review at each point should judge, in terms of optimization, congruity of the step with the overall program.

Fig. 3 illustrates a mathematical system optimizing the complex development.

Step_1. Overall scheduling. Make out an overall schedule from the following expressions producing annual demand of disposal and long-term storage.

$$Q(t) \geq W_d(t)$$
$$S(t) \geq W_s + w_d(t)$$

W = cumulative waste generation; W_d = portion of W to be disposed of; W_s = portion of W to be stored for a long time; w = annual waste generation; w_d = portion of w to be disposed of; Q = disposal capacity; S = storage capacity.

The schedule should include points of time and duration, disposal methods and capacities, and an arrangement of steps. The contents can be more specified with more detailed information on the waste in terms of generation and property.

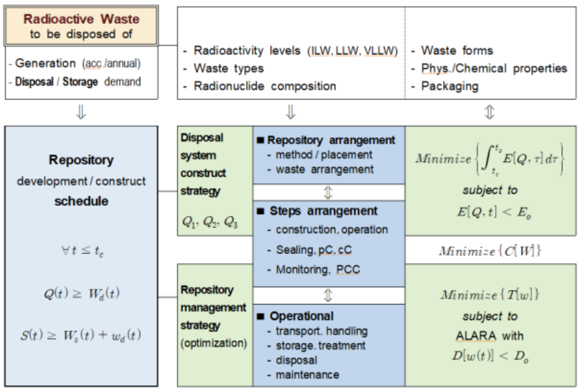

Fig. 3. An optimization scheme of systems analysis for planning the overall development of repository complex.

Step_2. Disposal system arrangement. Through the following expression, put the disposal method, disposal/storage capacity and the waste property from Step_1 into the disposal site to produce locations of the facilities from which the radiological consequence, E, is to be minimized:

$$Min. \int_{t_c}^{t_p} E[Q,\tau]d\tau \ \ subject\ to\ E[Q,\tau] < E_o$$

t_c = facility closing year; t_p = performance required period; E_o = performance objective (*e.g.*., 0.1 mSv/y).

Through this manipulation, some rearrangement may occur among capacities, methods, and facilities.

Step_3. Optimizing the repository operation. For the temporary setting through Steps_1 & 2, optimize the procedures and methods on an annual basis. This can be carried out by arranging individual elements in such a way that minimizes the total necessary time:

$$Min. \{T[w]\}\ subject\ to\ D[w] < D_o$$

D_o = annual dose constraint.

Step_4. Optimizing the complex development. In the repository complex, different steps of development may occur together with different facilities. Such situations also need optimizing throughout the overall repository period. For example, in the sense of efficient site management, they may be optimized in terms of the required cost, e.g., by minimizing $C[W]$ in such a comprehensive way that minimizes

$$\oint T[w(t)]dt,$$

where the line integral indicates that it should be performed via all steps during the overall development.

The output from Step_4 may be fed back into Step_1 to modify the draft schedule. Again, the result may be fed back repeatedly into Step_2, Step_3 and Step_4 for the overall rearrangement.

4. Constructing the reliable safety

Defense-in-depth arguments should be more emphasized for safety of the repository complex. For this purpose, understanding of the site characteristics should be enhanced throughout the repository development to find and upgrade the safety elements [2,3,4]. In order to assess safety features of the complex disposal system, it should be prerequisite to predict distributions of the contaminants over the site with the system evolution, which is required for an integrated compliance assessment with the safety objectives. In addition, it should be remembered that credible information on the waste is an essential element for a valid development and the safety case. For example, relevant arrangement between disposal facilities and the dynamic properties of waste forms may result in less consequence with less uncertainty.

5. Concluding remarks

Gyeongju repository is a national infrastructure for the sustainable application of nuclear energy. A systematic safety case based on timely consideration of safety elements is necessary for the prosperous complex development. For this purpose, the overall program optimization should continue step by step with updated characteristics of the waste and the site. The considerations discussed here may provide some ideas for establishing a solid overall development program and for its optimization.

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