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RISK-BASED APPROACH TO LONG-TERM SAFETY ASSESSMENT FOR NEAR SURFACE DISPOSAL OF RADIOACTIVE WASTE IN KOREA

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Abstract

This paper presents the Korean regulatory approach to safety assessment consistent with probabilistic, risk-based long-term safety requirements for near surface disposal facilities. The approach is based on:

(1) From the standpoint of risk limitation, normal processes and probabilistic disruptive events should be integrated in a similar manner in terms of potential exposures; and
(2) The uncertainties inherent in the safety assessment should be reduced using appropriate exposure scenarios.

In addition, this paper emphasizes the necessity of international guidance for quantifying potential exposures and the corresponding risks from radioactive waste disposal.

1. INTRODUCTION

Radioactive waste disposal shall be carried out in such a way as to demonstrate that the associated potential hazards will be acceptable [1]. Such a demonstration may be established through a systematic safety assessment, which evaluates the performance of the overall disposal system and its radiological impact on human health and the environment.

In Korea, near surface disposal is designated as the disposal method for low- and intermediate-level radioactive wastes. The Korean Atomic Energy Act prescribes the long-term safety requirements for near surface disposal in terms of a risk constraint, which requires a probabilistic, risk-based approach to the safety assessment. The Korea Institute of Nuclear Safety (KINS), the nuclear regulatory institute in Korea, is currently considering how to implement the risk-based safety requirements for near surface disposal [2]. This paper describes KINS' approach to this subject.

2. REQUIREMENTS AND ISSUES FOR LONG-TERM SAFETY ASSESSMENT

The Korean regulatory framework is well established for near surface disposal. It provides long-term safety requirements for near surface repositories in concrete terms, including:

(1) Compliance with the IAEA safety principles [1] shall be assured;
(2) The individual radiological risk shall not exceed 10^{-6}/yr;
(3) The period of compliance for meeting the individual risk requirement need not exceed 1,000 years, while the risk shall not abruptly increase beyond this time; and
(4) The risks shall be calculated based on either dose estimates from deterministic analysis or the mean value of dose distribution from probabilistic analysis, with probabilities of occurrence of exposure scenarios and the risk coefficient of 5.0×10^{-2} /Sv [3].

The specified period of compliance, 1,000 years, is relatively short compared with those being considered in other countries [4]. But it reflects some restrictive factors such as the characteristics of radioactive wastes to be disposed of in near surface disposal facilities, the geohydrological nature of Korea, and the amplification of complexity and uncertainty with time. Since the framework adopts a risk limitation system for controlling the potential exposure from radioactive waste disposal rather than a dose limitation system, these requirements need implementing by an overall probabilistic safety assessment.

The performance of near surface repositories depends upon various factors, such as waste form and content, engineered barriers, and site characteristics, which may govern source terms and radionuclide transport. For their post-closure phase, the major safety issues are related to the potential radiation exposure and the associated uncertainties over periods far into the future [5]. Consequently, a systematic long-term safety assessment must project the effects of such governing factors on the potential exposure over the long time period, estimating the uncertainties involved in the projection while minimizing their inflow. In the Korean situation, such points should be managed within a probabilistic, risk-based framework.

3. DEMONSTRATION OF COMPLIANCE WITH PERFORMANCE OBJECTIVE

The safety requirements described above may be condensed into a performance objective such that the following condition should be satisfied for representative members of the critical groups in connection with the potential exposure over 1,000 years from disposal [6]:

$$\max_i \left[R_i \equiv \sum_j P_{ij} \cdot E_{ij} \cdot F \right] \leq 10^{-6}\,/\,\mathrm{yr}$$

,

where R_i denotes the annual risk expected for the ith year, P_{ij} is the probability of occurrence of exposure scenario j for the ith year, E_{ij} is the committed effective dose from exposure scenario j in the ith year, and F is the risk coefficient. If, after considering the magnitude and time of the consequence, and associated uncertainty, we decide that the performance objective is not met, we should impose inventory limits for the problem waste, or improve the design of the repository, else reject the proposed disposal system.

The performance of a repository should be consistent with general radiological protection principles, while the same radiological protection principles should be adhered to throughout a time frame for a given safety assessment [1,7]. In terms of potential exposure, it is reasonable that normal processes and probabilistic disruptive events be integrated in a similar manner [6,8,9]. In this context, the risk limitation expressed above may allow us to maintain a coherence in treating exposures from normal processes such as radionuclide transport by groundwater and exposures from low-probability abnormal events such as inadvertent human intrusion into the disposal system.

The uncertainties inherent in the safety assessment should be treated as clearly as possible to demonstrate, with reasonable assurance, that the performance objective will be met. The possibility of exposure is the most significant contributor to uncertainty in the estimation of potential exposure. In general, the uncertainty in estimating the probability of occurrence is much greater than the uncertainty in estimating the probability of the consequence in the case of the occurrence of exposure. Therefore, reasonably conservative scenarios should be identified and used in the safety assessment in order to reduce inflow of such uncertainty by covering other minor scenarios. In addition, unnecessary speculations should be excluded in selecting scenarios since they will amplify uncertainty during the safety assessment and finally invalidate the risk limitation system.

The concept of risk, on which the approach discussed above is based, is not easy to apply in real situations. For this concept to be more effective, an international guidance for treating potential exposure should be established for disposal application. In order to overcome the weaknesses of this concept, it may be desirable to introduce some dose-based elements to the risk limitation system. For example, we may have an additional performance criterion that the 95th percentile of the total risk distribution should not be greater than 5 x 10^{-5}/yr [4,10], which is equivalent to the dose limit of 1 mSv/yr.

4. CONCLUSION

This paper presented an approach for demonstrating compliance with probabilistic, risk-based long-term safety requirements for near surface disposal in Korea. The approach integrates normal processes and probabilistic disruptive events coherently based on risk limitation. In order to make the safety assessment valid, it tries to reduce uncertainties inherent in the safety assessment by appropriate selection of exposure scenarios. In Korea, a similar approach is going to be applied to the deep geological disposal of high-level radioactive waste as well.

The risk-based approach is consistent with the concept of potential exposure. Although there are still a number of problems surrounding the approach, they can be resolved based on international guides on this subject. We believe that this approach will provide a reliable estimate of performance for a safety assessment with reasonably conservative modeling.

Reference

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Principles of Radioactive Waste Management, Safety Series No. 111-F, IAEA, Vienna (1995).

[2] JEONG, C. W., et al., "Technical consideration on a safety assessment methodology for low- and intermediate-level radioactive waste disposal facilities", Proceedings of the Korean Nuclear Society Autumn Meeting, Seoul, Korea (October 1999).

[3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the ICRP, Publication 60, ICRP (1990).

[4] U.S. NUCLEAR REGULATORY COMMISSION, Branch Technical Position on a Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities, Draft for Public Comment, NUREG-1573, US NRC (1997).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Near Surface Disposal, Safety Series No. 111-G-3.3, IAEA, Vienna (1997).

[6] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection from Potential Exposure: Application to Selected Radiation Sources, Publication 76, ICRP (1997).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Near Surface Disposal of Radioactive Waste, Safety Series No. 111-S-3, IAEA, Vienna (1997).

[8] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection from Potential Exposure: A Conceptual Framework, Publication 64, ICRP (1993).

[9] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Radiation Protection Principles for the Disposal of Solid Radioactive Waste, Publication 46, ICRP (1985).

[10] SAVAGE, D. (Ed.), The Scientific and Regulatory Basis for the Geological Disposal of Radioactive Waste, John Wiley & Sons, Inc. (1995) 362 pp.