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Approach for Assessing Human Intrusion into a Radwaste Repository

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1. Introduction

It is the preferred option to contain the radwaste and isolate it from the human environment for a long-term management of the radwaste. The concentration and containment of the waste in one location, however, could make future generation be in hazard condition if someone were to disturb the disposed waste.

An approach to assess human intrusion into radwaste repository resulting from future human actions was proposed based on the common principals, requirements, and recommendations from IAEA, ICRP, and OECD/NEA, with the assumption that the intrusion occurs after loss of knowledge of the hazardous nature of the disposal facility.

At first, the essential boundary conditions were derived on the basis of international recommendations, followed by overall approach to deal with inadvertent human intrusion.

2. Premises for Human Intrusion

2.1 Constraints vs. optimization

The IAEA Specific Safety Requirements for Disposal of Radioactive Waste (SSR-5) describes guidelines regarding human intrusion: *(e) If annual doses in the range 1-20 mSv are indicated, then reasonable efforts are warranted at the stage of the development of the facility to reduce the probability of intrusion or to limit its consequences by means of optimization of the facility designs* [1]. This statement recommends the human intrusion be interpreted as the optimization rather than compliance to satisfy dose constraints in the cases where estimated doses are in the range 1-20 mSv/yr. Therefore, the human intrusion should be dealt with in terms of optimization process to enhance the robustness the disposal facility and to reduce the consequence of the hazard when the intrusion occurs.

2.2 Future human actions

It is important to determine which future human actions should be considered in the human intrusion scenarios. The IAEA Specific Safety Guide for Safety Case and Safety Assessment for the Disposal of Radioactive Waste (SSG-23) states: *Only those human actions that result in direct disturbances of the disposal facility (i.e. the waste, the contaminated near field or engineered barriers) are considered human intrusion* [2]. Therefore, potential human actions making outside the contaminated near field doesn't need to be considered.

2.3 Human action scenarios

Because the estimate of probability of future human intrusion is highly uncertain, it is not acceptable by the public to consider detailed human action scenarios. ICRP Publication 81 [3] states: *Because the occurrence of human intrusion cannot be totally ruled out, the consequences of one or more typical plausible stylised intrusion scenarios should be considered by the decision-maker to evaluate the resilience of the repository to potential intrusion*. The IAEA, ICRP and NEA also recommend that the scenarios should be developed to explain the robustness of the disposal system rather than speculating all possible intrusions. Therefore, a set of stylized human action scenarios should be used to illustrate impacts of the human intrusion on the disposal facility rather than to judge whether the human intrusion scenario would satisfy the dose constraints of the disposal facility

2.4 Advertent vs. inadvertent intrusion

SSG-23 discusses "*In the safety assessment for a waste disposal facility, inadvertent (unintentional) human intrusion should be considered but quantification of the potential risks associated with deliberate intrusion need not be carried out.*" OECD/NEA also describes that the current society doesn't need to protect the future generation from their actions they will carry out with recognition that the hazardous radwaste exists [4]. Therefore, only inadvertent human intrusion needs to be considered.

2.5 Timing of intrusion

Time at which the human intrusion occurs is closely related to institutional controls in near-surface repository and passive controls in deep geological repository [5,6,7]. As long as the knowledge on the repository maintains, the inadvertent human intrusion will not occur. For a near-surface repository, it is conservative to assume that the human intrusion occurs immediately after the institutional control period ends. For a deep geological repository, the institutional control might not be implemented because the deep geological repository should be assured in terms of safety by means of passive measures. As long as the passive controls exist, the human intrusion may not occur. Because the passive controls in a deep geological repository are closely related to knowledge preservation, it seems reasonable to assume that the human intrusion would occur immediately after the knowledge of the repository site and information on disposed radwate is lost for a deep geological repository.

2.6 Future habits

It is definite that technologies in the future will be advanced than current technologies in light of past advance of the technology. However, the possibility of loss of all current technologies by diseases, financial crisis, and world war cannot be ignored as well. Therefore, it seems to be reasonable to assume that future habits and residential customs are similar to those of current society to avoid speculation.

3. Approach for Assessment of Human Intrusion

3.1 Overall approach

The eventual purpose to assess human intrusion is to derive the measures against human intrusion into disposal facility to enhance the robustness of the facility and reduce the potential for and/or consequence of human intrusion. Figure 1 shows overall approach to assess human intrusion into repository. It begins with identification of safety framework including safety case context, safety strategy, and description of disposal system. The stylized scenarios and potential measures are identified in the next step where site- and facility-specific scenarios and potential measures are derived. The societal factors such as technologies, habits, and institutional controls are considered when the scenarios and potential measures are determined. Finally the protective measures against human intrusion are derived through quantitative or qualitative assessments based on the human intrusion scenarios and potential measures.

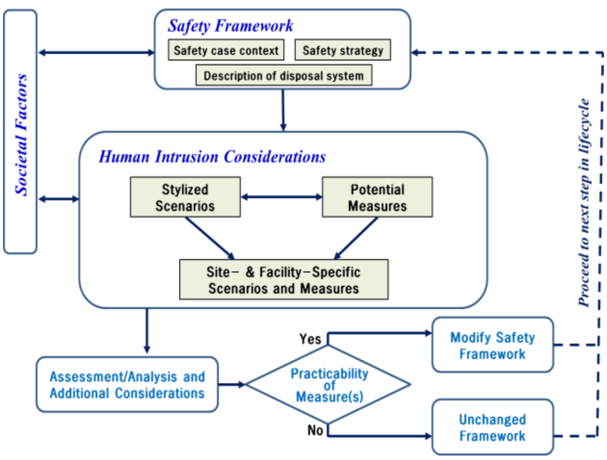

Fig. 1. Assessment Flow of Human Intrusion.

Although the measure derived in the final step is efficient to protect or reduce potential of human intrusion, if the measure jeopardizes the safety function of the disposal facility, the measure cannot be accepted as a protective measure.

3.2 Procedure for derivation of protective measures

Step 1: Definition of the framework

The aim of this step is to analyze safety framework to derive national regulatory basis (e.g. acts, regulations, and ordinances and possible conditions and provisions) to be considered when human intrusion is assessed. The essential boundary conditions such as period of institutional control, consideration on technology and habits in the future society are also identified in this process. The specific requirements in terms of implementation of some measures are also identified. For example, if the law prohibits the installation of marker in the disposal facility like Germany or Sweden, implementation of the marker as a potential measure is excluded in the step 3.

Step 2: Compilation of general measures

The step 2 includes identification of general measures which can be considered in the process of deriving potential measures. Database on general measures applicable to disposal facilities are established in this step. When the general measures are identified, the site, characteristics of host rock, disposal concept, disposal system, etc. are not considered. This database can be updated by the input from experts in various fields as the disposal system design evolves. These general measures are used as input in step 3 when the potential measures are derived.

Step 3: Identification of potential/inherent measures

The potential measure represents the measure that is appropriate candidate for eventual protective measure. In this step, potential measures are derived by taking into account the characteristics of the site, disposal system design, waste characteristics and forms, disposal concept, and design layout. Prior to derivation to potential measures, it is important to derive inherent measures which are already implemented in disposal design like depth to enhance effectiveness of inherent measures during optimization process. The potential measures should be derived by taking into account followings: a) the measures shall not compromise safety function of disposal system, b) the measures shall not give rise to negative impacts on human and environment, and c) the measures should have competitiveness in terms of benefits, effort, and cost, which will be taken into account as part of optimization.

Step 4: Derivation of protective measures

The potential measures are assessed qualitatively or quantitatively on the basis of site- and facility-specific scenarios and potential measures to judge whether the potential measurer derived in step 3 are appropriate as protective measures. At first, the potential measures are primarily assessed in terms of conflict with safety function of the disposal facility, and then the feasibility of implementation and effectiveness of reducing the potential for and/or consequence of human intrusion. The evaluation of the effectiveness is performed by discussing or estimating the cases with and without the potential measure. The potential measure is accepted as a protective measure when the measure doesn't jeopardize safety function and the implementation is possible.

4. Summary and Conclusion

An overall approach to access inadvertent human intrusion into radwaste repository was proposed with the assumption that the intrusion occurs after loss of knowledge of the hazardous nature of the disposal facility. The essential premises were derived on the basis of international recommendations, followed by overall approach to deal with inadvertent human intrusion. The procedure to derive protective measures was also explained with four steps regarding how to derive safety framework, general measures, potential measures, and eventual protective measures on the basis of stylized scenarios.

It is expected that the approach proposed in this study will be effectively used to reduce the potential for and/or consequence of human intrusion during entire processes of realization of disposal facility.

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