Consideration on Potential Measures against Human Intrusion for a Near Surface Disposal Facilities

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1. Introduction

It is a commonly used strategy to contain the radwaste and isolate it from the human environment for safe management of the radwaste. The strategy of containment and concentration in one location, however, can cause future generation to be in hazard condition if someone made disturbance to the disposed waste.

The IAEA Specific Safety Requirements for Disposal of Radioactive Waste (SSR-5) describes guidelines regarding human intrusion that reasonable efforts to reduce the probability of intrusion or to limit its consequences by means of optimization of the facility designs are warranted, if annual doses in the range 1-20 mSv are indicated [1]. This means that protective measures are recommended to enhance the robustness of the disposal system and to reduce the consequence of the hazard when the intrusion occurs.

In this paper, candidate measures which could be implemented in a near surface disposal facility were proposed, and then potential measures which could be implemented in the hypothetical near surface disposal facility were suggested.

2. Assessment of Human Intrusion

2.1 Guidance from IAEA

Safety criteria in the section of radiation protection in the post-closure period of SSR-5 are as follows: *(c) in relation to the effects of inadvertent human intrusion after closure, if such intrusion is expected to lead to an annual dose of less than 1 mSv to those living around the site, then efforts to reduce the probability of intrusion or to limit its consequences are not warranted; (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].

According to the above guidance, while no further action is needed when expected dose induced from inadvertent human intrusion is below 1 mSv/yr, specific measures to reduce the potential for and/or consequence of the intrusion are recommended to be implemented in the siting, design, construction, operation, closure, and institutional control of a near surface disposal facility.

2.2 Guidance from HIDRA Project [2, 3]

Figure 1 shows overall approach to derive protective measure against human intrusion into repository for optimization of disposal facility proposed by HIDRA international project.

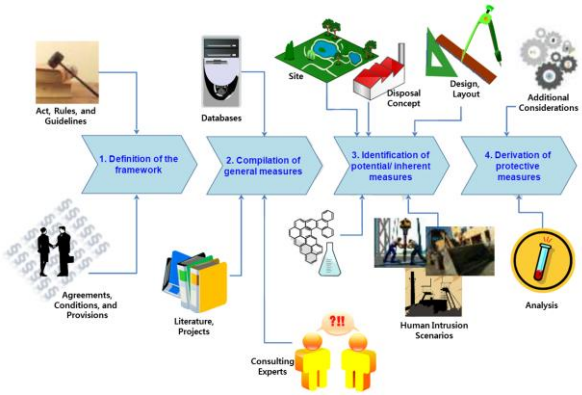

Fig. 1. Assessment Flow for Protective Measure [3]

The 1st step begins with identification of safety framework by investigating national regulatory basis to be taken into account when human intrusion is assessed. The boundary conditions such as period of institutional control, consideration on technology and residential habits that the future society would have are also identified during this process.

In the 2nd step, general measures which can be considered in the process of deriving potential measure are considered. Database on general measures applicable to disposal facilities are established without taking into account the site, characteristics of host rock, disposal concept, disposal system, etc. This database can be established by brainstorming or input from experts in various fields as the disposal system design evolves. These general measures are used as input in the 3rd step for the derivation of potential measures.

In the 3rd step, the potential measure that is a candidate for derivation of eventual protective measure is identified. A potential measure is determined by reflecting characteristics of the site, waste characteristics and forms, disposal concept, disposal system design, and design layout. The potential measure should be derived on the basis of followings: a) the measure shall not compromise safety function of a disposal system, b) the measure shall not make negative

impacts on human and environment, and c) the measure should be justifiable in terms of benefits, effort, and cost.

At final step, a protective measure is derived by assessing the potential measure qualitatively or quantitatively on the basis of site- and facility-specific human intrusion scenarios. At first, the potential measure is 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 the intrusion. The effectiveness is analyzed by discussing or estimating the cases with and without the potential measure. The potential measure is finally accepted as a protective measure when the potential measure doesn't compromise safety function and the implementation is possible.

The protective measures are iteratively modified and updated over the lifecycle of the disposal facility. Please refer to references 2 and 3 for more information.

3. Potential Measures

3.1 Measures for Reduction of Risk

According to Ordinance 2015-021 of Nuclear Safety and Security Commission, total risk is expressed by Eq. (1).

$$Total\ Risk = \gamma \sum P_i D_i \qquad (1)$$

Eq. (1) means that total risk is the product of the risk conversion factor multiplied by total dose induced from scenario *i* with probability of P_i. As shown in Eq. (1), the risk of the receptor can be decreased by the reduction of occurrence possibility of human intrusion scenario *i* and/or reduction of dose from the scenario *i*.

3.2 Disposal Facility

Hypothetical near surface disposal facility containing low-level radioactive waste was assumed to propose potential measures. Figure 1 shows conceptual drawing vault-type near surface disposal facility.

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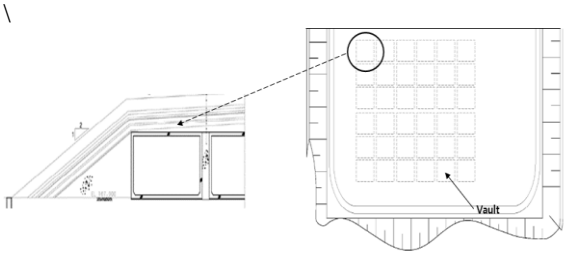

Fig. 1. Drawing of Hypothetical Disposal Facilities

This facility was assumed to be under conceptual design process and the facility will be built at Gyeongju repository site currently available in Korea. And, it has concrete engineered barrier with thickness of 30 cm, inside which 200 liter-drums are disposed of. The concrete vault is covered by 5m-thick soil. And, backfill made of crushed rock and bentonite are assumed to be filled between concrete vaults.

3.3 Proposal on Potential Measures

Table 1 lists evaluation results for candidate potential measures regarding waste type and characteristics. Because potential measures are dealt with implementer of radwaste, WC-1 and WC-2 were excluded as potential measures because those two measures can be done by the waste producer rather than implementer in Korea. WC-3 was accepted because the case where relatively higher specific activity and intensity is deposited at the bottom of concrete vault gives rise to lower exposure dose to intruder when the same volume of the waste is brought to the surface on which intruder works The WC-3 has feature to reduce consequence of the intrusion.

Table 1. Potential Measures for Waste Characteristics

ID	Candidate Potential Measures	Evaluation
WC-1	Reduction of waste volume	X
WC-2	Waste conditioning of LLW	X
WC-3	Bottom emplacement of drums with relatively higher specific activity and radiation intensity	O

X: unacceptable, O: Acceptable

Table 2 lists evaluation results for candidate potential measures in relation to the site. Because the hypothetical disposal facility in this study was assumed to be built at Gyeongju repository site, there is no further way to avoid resources and to select regions with sparse populations. Installation of large crag on each vault can prevent public access, which results in reduction of likelihood of intrusion, however, this measure could jeopardize safety function of concrete vault induced by too heavy weight. Therefore these candidates were excluded as potential measures. Designation of Gyeongju repository site as prohibited zone for 500 years is a good way to prevent construction of residential house above the vault after currently available institutional control period of 100 years. And this measure doesn't compromise safety function and doesn't need much cost.

Table 2. Potential Measures for Site

ID	Candidate Potential Measures	Evaluation
ST-1	Selection of regions with sparse populations	X
ST-2	Selection of region without resources	X
ST-3	Installation of large crag heavier than 100 tons over concrete vault	X
ST-4	Designation as prohibited zone for Gyeongju repository site up to 500 years	O

X: unacceptable, O: Acceptable

Knowledge management is a good way to make likelihood of the human intrusion in terms of conflict

with safety function of disposal facility, cost effectiveness, and realization of the measures. Three potential measures which can reduce potential for the intrusion are listed in Table 3.

Table 3. Potential Measures for Knowledge Management

ID	Candidate Potential Measures	Evaluation
KM-1	Preservation of information and knowledge about near surface facility	O
KM-2	Establishment of an information center at repository site	O
KM-3	Archiving documents about near surface facility at national libraries	O

X: unacceptable, O: Acceptable

In the design stage many measures can be considered as potential measures for an optimization of near surface facility. The increase of depth of the vault up to 150 m was excluded because the vault with thickness of 30 cm can't withstand ambient pressure by host lock. Increase of wall thickness of drums up to 5 mm was excluded because it has small effect in terms of reduction of intrusion. FD-2, FD-3, FD-5, and FD-6 were adopted as potential measures to reduce likelihood of intrusion in Table 4. While FD-2 can reduce likelihood of the intrusion, it also increase consequence of hazard when intrusion occurs. The effectiveness of the FD-2 will be assessed further in the analysis to derive protective measure, as explained in Section 2 of this paper.

Table 4. Potential Measures for Facility Design

ID	Candidate Potential Measures	Evaluation
FD-1	Increase of depth of vaults up to 150m	X
FD-2	Reduction of footprint up to 50% by increasing height of the vault	O
FD-3	Insertion of stainless steel plate over each vault	O
FD-4	Increase of wall thickness up to 5 mm of 200-liter drums	X
FD-5	Insertion of a 20cm-thick reinforced concrete slab over near surface	O
FD-6	Installation of markers	O

X: unacceptable, O: Acceptable

In Table 5, potential measures in relation to monitoring and surveillance of the disposal site are listed. The extension of institutional period up to 500 years longer than currently scheduled period is one of the potential measures.

Table 5. Potential Measures for Monitoring/Surveillance

ID	Candidate Potential Measures	Evaluation
MS-1	Extension of institutional control period up to 500 years	O
MS-3	Installation of monuments on Gyeongju repository site	O
MS-4	Installation of signs, fences and guards at Gyeongju repository site	O

X: unacceptable, O: Acceptable

4. Summary and Conclusion

Potential measures were suggested with the assumption that hypothetical near surface disposal facility accommodating low-level waste will be built at Gyeongju repository site. Conflict with safety function of the facility and feasibility of implementation of the measures were mainly considered when candidate measures were evaluated. The potential measures were proposed under five categories of waste characteristics, site, knowledge management, facility design, and monitoring/surveillance.

It is expected that the potential measures proposed in this study will be effectively considered when the protective measures are derived for near surface disposal facility to be designed for the construction in Gyeongju repository.

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