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Preliminary Simulation of a Radiation Behavior in Large Scale Radiation Dose Facilities

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1. Introduction

Recently, the concern for proliferation resistance and physical protection has been increased than before. And the determination and criterion for radiation protection is of importance to provide safe and reliable guidelines for reduction of nuclear and radiation threat.[1][2] As a beginning work, two large scale gamma radiation dose facilities are chosen and basic simulations are performed by using of the MCNP6 code,[3] which is widely used to estimate radiation dose from the various radiation sources. Several scenarios are also assumed to provide accident cases such as source explosion and damaged shields. This data will play important role to set up the URC(unacceptable radiological consequence) guide in the near future.

2. Modeling of Large Radiation Dose Facilities

Two large scale radiation dose facilities are in operation in Korea, such as Greenpia Tech[4] and Soya GeenTec[5]. Table I shows the main characteristics for two facilities. The Co-60 gamma source is used in both facilities. Co-60 is obtained from neutron capture reaction of Co-59 and its half-life is about 5.27 years and is decayed into stable Ni metal. Two gamma energies are produced in Co-60 such as 1.17MeV and 1.33MeV. The manufactured source shape is a typical pencil type which is mainly made by the Canadian MDS-Nordion company.

The simplified MCNP models of two facilities are provided in Fig. 1. The thickness and fundamental data are come from basic design drawings. The radiation source is normally placed into the pool which is filled with water. The water is a good shielding material and coolant to remove heat from the source. Around source region, enough heavy concrete shield exists, which makes it difficult to intrude from outside, too.

3. Simulation of Radiation Distribution from the Damaged Source

It is assumed that several possible cases happen related with the source damage accident. When the pool water is lost, the radiation from source will propagate directly in the source region. However, it is confined in that region due to the heavy shielding wall. It is rarely possible to break the wall near source region.

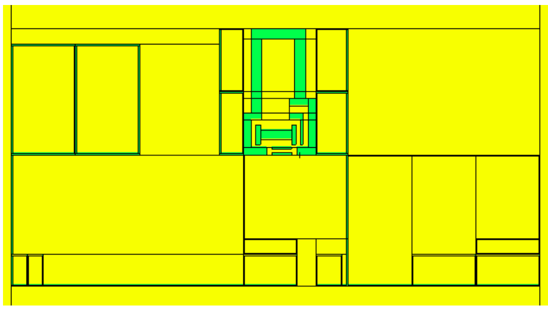
The MCNP6 code is used for the simulation and modeling. The used dose conversion factor is ICRP-74 data. And the number of particles is 1E8 for every case. All possible cases taken into considerations are summarized in Table II.

Fig.3 depicts the radiation distribution of two large scale facilities. Most cases except loss of wall, the radiations from source are distributed in the shielded irradiation region. Two facilities provide similar behavior due to similar design and same behavior of radiation source.

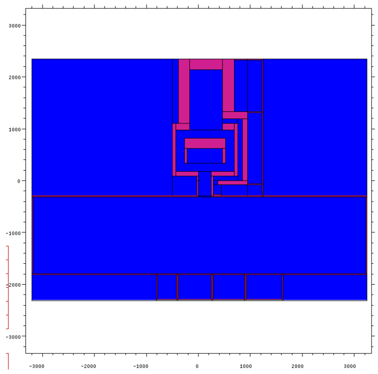
In the severe case, the sources are assumed to be damaged and they are scattered in the source region uniformly. Even though such an accident happens, most radiations are confined in the source irradiation region when the shield is not damaged significantly. It is thought that the shielding is almost maintained from the explosion due to its thickness is about 200 cm.

Table I: Description of Large Scale Radiation Dose Facilities

	Greenpia Tech	Soya Green Tec
Main source	Co-60	Co-60
Facility	JS8900 (MDS Nordion)	JS10000 (MDS Nordion)
Capacity	2E6 Ci (Max. 5E6 Ci)	8E5 Ci (Max. 5E6 Ci)
Main Target	Sterilization Items	Medical instruments



(a) MCNP model for Greenpia Tech

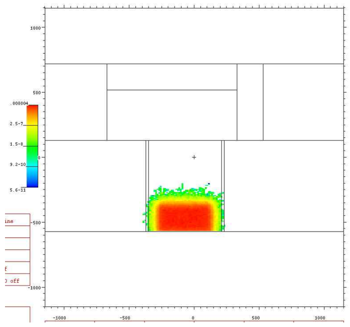


(b) MCNP model for Soya GreenTec

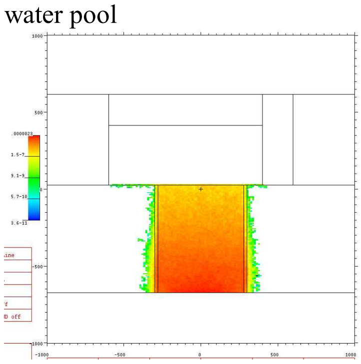
Fig. 1. MCNP model for two large scale radiation dose facilities.

Table II: Various Accident Cases in Large Scale Radiation Dose Facilities

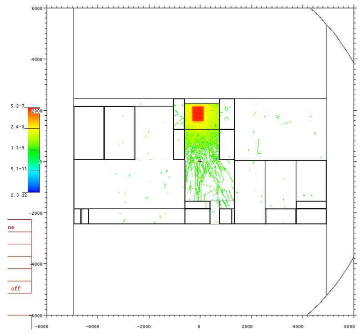
	Normal state	Accident state
Source Pool	Water	Air
Shield wall	Concrete	Air (damaged state)
Source Position	In the Pool	Out of pool
Source Shape	Concentrated in the pool region	Scattered in source region



(a) Vertical view when source in located in the water pool



(b) Vertical view when pool water is lost and filled with air



(c) Horizontal view of case (b) and walls are damaged

Fig. 2. Radiation distribution for various cases in Greenpia

From the output, the source contribution to the outer region is very small due to heavy shielding walls. From the Fig. 3, the ratio of outer region from the source is about 1E-5 ~ 1E-6, which is almost negligible. But the outer shield is maintained from the explosion attack, the outer region is almost clean as shown in Fig. 4.

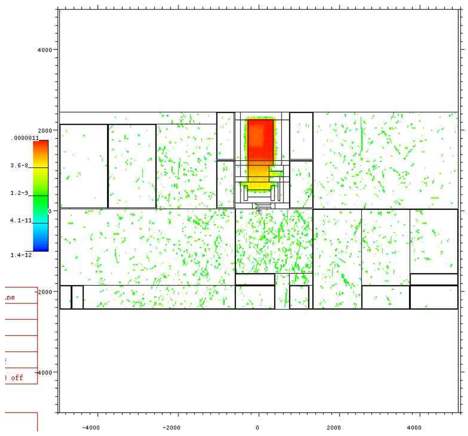


Fig. 3. Radiation distribution for damaged source case in Greenpia Tech when the shield is damaged.

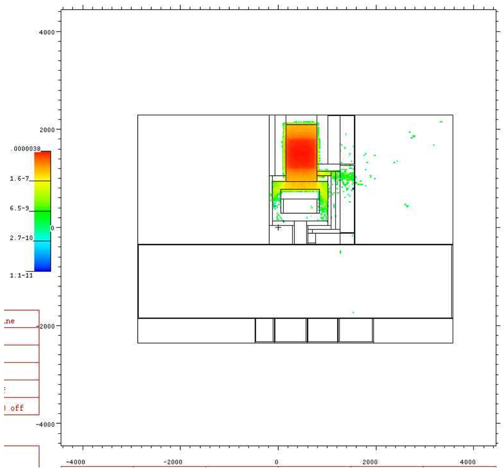


Fig. 4. Radiation distribution for damaged source in Soya GreenTec when outer shield is maintained.

4. Conclusions

Various simulations of the damaged source have been carried out for the two large scale radiation dose facilities by using the MCNP6 code. In the several severe cases, the contribution from source is not significant. Due to characteristics of Co-60 source, the surround wall and pool water is well equipped in two facilities even though an inner explosion accident.

As a future work, additional nuclear related facilities are applied based on the same approach in this study. These data will be utilized to establish URC concept for various radiation facilities in Korea, too.

REFERENCES

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