Radiation Shielding Evaluation for Spent Fuel Storage Pool According to Burnup

Young-Hwan Choi*[1], Jae-Hun Ko[1], and Ki-Young Kim[2]

[1]Korea Nuclear Engineering & Service, #5, Hyundai Plaza, 798-1, Yuseong-daero, Daejeon, Republic of Korea

[2]KHNP Central Research Institute, 1312-70, Yuseong-daero, Yuseong-gu, Daejeon, Republic of Korea

*Sarn2000@kones21.com

1. Introduction

The spent fuel pool is equipped with storage racks designed to hold the spent fuel assemblies removed from the reactor and is typically 12 meters or more deep to keep radiation levels below acceptable levels. Therefore, the spent fuel storage pool is shall secure the radiological safety for a person working around the storage pool through the analysis for the capacity and specifications of the stored spent fuel.

This paper addresses the radiation dose rate at the water surface of the spent fuel pool were addressed by considering storage capacity and burnup for the spent fuel pool of the HANUL unit 3.

2. Shielding Evaluation of Spent Fuel Pool

2.1 Acceptance Criteria

Spent Fuel Storage Pool is classified as nuclear fuel facilities under the domestic nuclear safety act, must comply with the Nuclear Safety Commission Regulation No. 19. Therefore, the radiation dose rate on the water surface of the pool should not exceed 25μSv/hr.

2.2 Specification of Spent Fuel

The evaluated spent fuels were selected from spent fuels released from reactor of HANUL unit 3, and the source term was evaluated according to the burnup rates. The specifications of the evaluated spent fuels were assumed to be of various burnups up to maximum 60,000MWD/MTU and 5.0wt% enrichment. Table.1 shows the specifications of the spent fuels applied in the source term evaluation.

Table 1. Specification of Spent Fuel

Fuel Type	Enrichment [wt%]	Burnup [MWD/MTU]
CE Type PLUS7	5.0	50,000
		55,000
		60,000

2.3 Radiation Source

In general, radiation source term in the spent fuel storage pool is calculated considering a number of spent fuels stored in the storage racks (region II) and one fuel assembly in transit from region I to region II. Primary gamma rays and neutrons generated from spontaneous fission and (α, n)reaction of fissile materials were calculated considering the burnup and cooling time of the spent fuel using the ORIGEN-ARP modules of SCALE 6.0 computer code[1]. But the effects of radiation dose rates by neutron and secondary gamma excluded in this evaluation because they are relatively very small compared to dose rate by primary gamma source.

Fig. 1 shows the gamma spectrum according to energy of the spent fuel with a typical burnup of 60,000 MWD / MTU. The blue line and red line of the Fig. 1 mean gamma sources for a spent fuel which cooling time is 150hr, and the average value of 1,232 spent fuels stored in the region II.

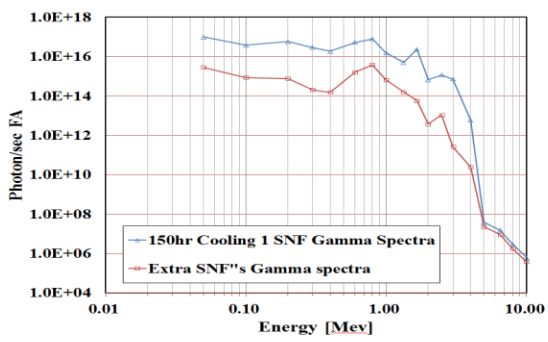

Fig. 1. Gamma spectrum of the Spent Fuel.

2.4 Radiation Shielding Evaluation

The spent fuel storage pool of the HANUL unit 3 is the concrete structure filled with water with the inside of the 12 m height. The storage rack consists of Region I, which 177 fuels for emergency storage of nuclear fuel of the reactor, and Region II, where 1,232 spent fuels is stored. MCNP6 computer code was used for shielding evaluation of spent fuel storage pool. MCNP6 computer code calculates transport equation for photons, neutrons and electrons, etc. using the three-dimensional Monte Carlo method[2].

To calculate dose rates at the various locations on external surface of the spent fuel storage pool, eight virtual tallies were placed. Fig. 2 shows shielding evaluation model of the spent fuel storage pool.

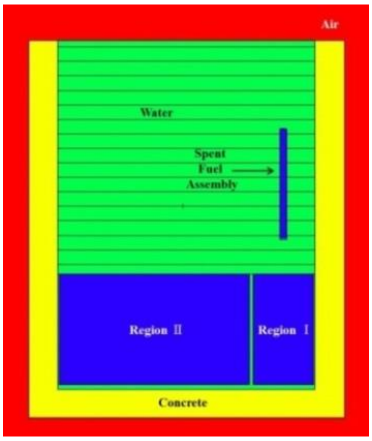

Fig. 2. Shielding Evaluation Analysis Model.

3. Result

Table 2 shows the radiation dose rate on the external surface of a spent fuel storage pool according to burnup, and it shows the largest radiation dose rate among the eight virtual tallies. Relative errors of these virtual tallies are showed 0.06~0.1. Fig. 3 shows the distribution of the radiation dose rate according to various positions and the dose rate of a virtual tally located in the center of the Region Ⅰ shows the largest. Table 3 shows the dose rates according to the presence or absence of fuel assembly in transit. This is the result of the dose rate at the maximum burnup of 60,000 MWD / MTU. As the result, we confirmed that the dose rate of a fuel assembly in transit is dominant in this analysis.

Table 2. Dose Rates Result

Burnup [MWD/MTU]	External Surface [μSv/hr]	
	Result	Limit
50,000	23.1	25
55,000	23.8	
60,000	24.4	

Table 3. Dose Rates with(or without) a FA in transit

Condition	External Surface [μSv/hr]
With a FA in transit	24.3
Without a FA in transit	9.2×10^{-5}

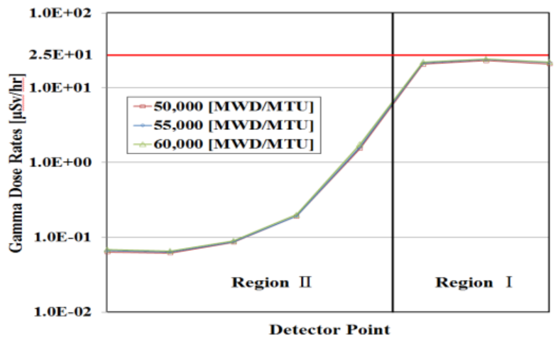

Fig. 3. Distribution of Dose Rates.

4. Conclusion

Radiation shielding evaluation of spent fuel storage pool in NPP was performed. As can be seen from the evaluation results, the radiation dose rate on the external surface of the spent fuel storage pool meets the acceptance criteria even though the spent fuel is burned up to 60,000 MWD/MTU. Also, we confirmed that the radiation dose rate of a fuel assembly in transit is dominant.

REFERENCES

[1] Scale: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design, Version 6.1 (2011).

[2] Los Alamos National Laboratory, "A General Monte Carlo N Particle Transport Code, Version 6.0", MCNP6, Rev.0 (2013).