Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

Radiological Assessment of Dose Distribution around the RPV for Decommissioning of Nuclear Power Plant

TaeHyoung Kim, Geun-Ho Kim, Kwan-Seong Jeong, Dongjun Hyun, Jeikwon Moon, and Byung-Seon Choi
Korea Atomic Energy Research Institute, 1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea

1. Introduction

The nuclear facility such as NPP(Nuclear Power Plant) has been decommissioned because of losing its function or safety from its ageing.

The radiological effect must be assessed for decommissioning of NPP after shutdown, because it is different from industrial facility. The radiological assessment for decommissioning can be divided into the radioactivity inventory assessment and the space dose assessment of the facility [1].

Especially, to design the decommissioning scenario under the ALARA principle and to calculate exposure dose rate for worker, the assessment of the space dose in this facility is important.

In this study, the dose distribution around Kori-1 was assessed for the utilization of reasonable design of decommissioning scenario by MCNP code.

2. Modeling and Simulation

The space dose distribution around RPV and biological shield areas in Kori-1 NPP was evaluated using MCNP code (build 1.40).

In this study, these areas were selected from the following assumptions: First, the radiation has been no effect at outside of biological shield. Second, there was no effective valid workspace for decommissioning except for selected areas.

Modeling and simulation were conducted by following three main steps.

2.1 Geometric structure modeling

According to drawings of Kori-1, the geometrical model for the RPV and biological shield was designed to protect the radiation to outside. The geometrical model is shown in Figure 1.

The RPV is overall cylindrical-type, and its head and bottom are hemispherical-type. It has 1,147 cm length, 169 cm diameter, and 16.8 cm thickness. There are two pairs of nozzles at the upper part of RPV.

The biological shield can be divided into the lower part and the upper part. The lower part is from 200 cm to 267 cm thickness and cylindrical-type structure. The upper part is about 30 cm thickness and rectangular-type.

The materials of RPV and biological shield are made of carbonsteel (2.24 g/cm^3) and concrete (7.86 g/cm^3), respectively.

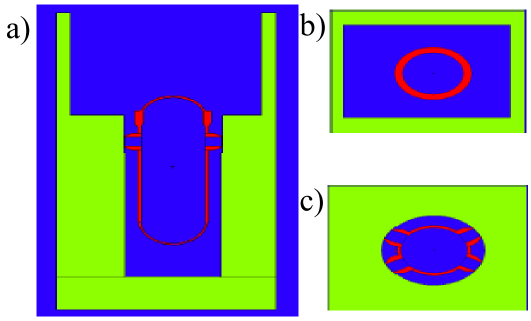

Figure 1. The geometrical model for Kori-1 RPV. (a : vertical cross section through the modeling, b: horizontal cross section at the RPV pool, c: horizontal cross section at the nozzle area)

2.2 Source modeling

^{60}Co nuclide was chosen as the main effective radionuclide because it contributes greatly to the exposure dose of worker and is relativity long-lived nuclide among radionuclides in decommissioning. The concentration of ^{60}Co was obtained from the existed data [2]. This concentration was converted to the time of 5 years later after shutdown of Kori-1 NPP which has been operated for 40 years.

The active reactor core was divided into 3 parts from the top to bottom for the simulation. It was assumed that the concentration of ^{60}Co to each part was changed stepwise as shown in Figure 2 even though it originally had continuous distribution.

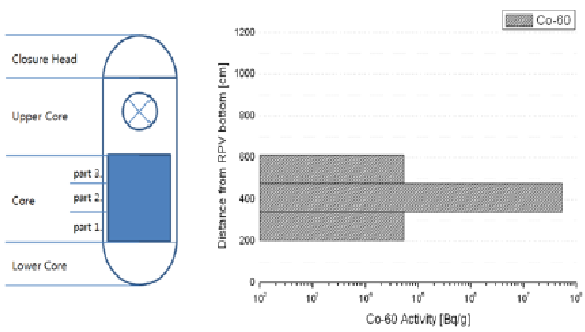

Figure 2. The concentration of ^{60}Co nuclide at the RPV according to the location

2. 3 Method of dose assessment

The dose calculation regions were composed of two parts. One is between the RPV and biological shield of cylindrical-type, and the other is at the RPV pool of rectangular-type.

The dose calculation was calculated by fmesh-tally function for 6,496 dose measurement areas around the RPV and its surroundings.

Finally, the fmesh-tally output was converted to the dose rate by flux to dose conversion factor from ICRP 60.

3. Results and Discussion

To decide reasonable working positions in decommissioning scenario, two dose distributions was analyzed. One was dose distribution between RPV and biological shield. The other was dose distribution in the top of biological shield.

The dose rates between RPV and biological shield were changed along the height of RPV shown in Figure 3. The highest dose value was 22.9 Sv/h and its height was 4.35 m from the bottom of RPV. This illustrated that the more height of other dose values are long distance from that of the highest dose value, the less other dose values had a tendency to decrease like bell-shape distribution shown in Figure 3. The dose above nozzle was relatively low. These results meant that decommissioning work with direct access of worker is permissible above height of about 1,000 cm, but decommissioning work with direct access of worker needs protective actions under height of about 1,000 cm.

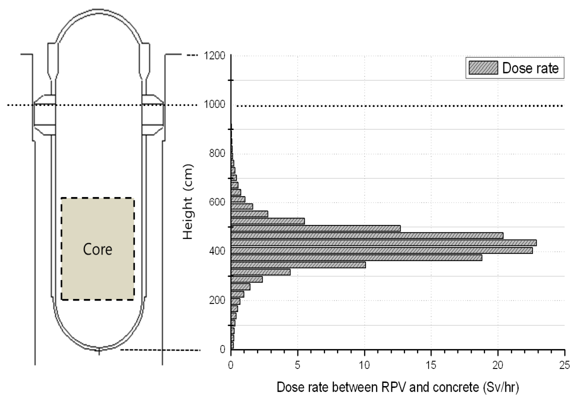

Figure 3. Dose distribution between RPV and biological shield in the z-axis direction

The dose rates in the top of biological shield were shown in Figure 4. This result was symmetric with both X-axis and Y-axis. The minimum value (1.2 mSv/h) was presented in the center of the upper area at the RPV head. The maximum value (10.8 mSv/h) were presented at the center of both ends on y-axis (x : 70 cm, y : -310 cm and x : -32 cm, y : 341 cm), respectively. Figure 4 also showed that the values of both ends on Y-axis were higher than the values of both ends on X-axis, because two nozzles were located at both ends on X-axis. These results showed that the RPV head and nozzles functioned as a shielding material.

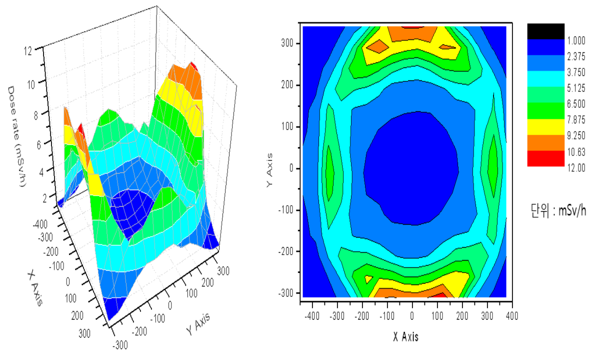

Figure 4. Dose distribution in the top of biological shield (working floor area)

4. Conclusions

In this study, the distribution of dose rate around the RPV in Kori-1 was calculated by MCNP and assessed to help design the reasonable decommissioning scenario.

Assuming that NPP was operated for 40 years and cooled for 5 years after its shutdown, the highest dose value was 22.9 Sv/h at 4.35 m height and the lowest dose value was 10.8 mSv/h at the top of biological shield. According to the domestic criteria, the dose limits for workers is 100 mSv/5 yrs and 50 mSv/yr. From these calculation results, it is apparent that the dose is so high that worker couldn't work around the RPV without protective actions of radiation. However, these results can be decreased through the several decontamination steps to reduce the radioactivity.

Future plan is to assess distribution of space dose including various factors such as cooling time and decontamination methods and adding the internal structure of RPV.

REFERENCES

[1] Anibal L. Taboas, A. Alan Moghissi, Thomas S. LaGuardia, The decommissioning handbook, ASME, New York, 2004

[2] KINS, Study on the safety evaluation Method development for D&D of Nuclear power plant, KINS/HR-444, 2002

[3] IAEA, Radiological characterization of shutdown nuclear reactors for decommissioning purposes, Technical Report Series No.389, 1998