Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 23-24, 2019

Radiation Sensitivity Analysis for Uranium-containing Hydrofluoric Acid

Kyoungyong Noh [a], Hyun Sik Kang [a], Misuk Jang [a*], Seoung Rae Kim [a]
[a]*Nuclear Engineering Co., Ltd., Engineering Research Institute, 277 Baeul1ro, Yuseong-gu, Daejeon, Korea, 34036*
[*]*Corresponding author: msjang@ness.re.kr*

1. Introduction

In this paper, we analyzed the effect of radiation source size on radiation dose and examine the effectiveness of modeling the whole structure.

The target of the evaluation is a tunnel, which is simple structure that requires less time to evaluate and one of the structures using concrete accelerator. The concrete accelerator is an additive during repair work such as tunnels and road slopes and one of the recycling methods of hydro-fluoric(HF) acid generated in the uranium fuel manufacturing facility. It is assumed that this hydrofluoric acid actually contains little uranium but contains the lower limit of analytical instrument.

2. Methods and Results

2.1 Model and Methods

In this study, it is based on Inje - Yangyang Tunnel which is the longest domestic tunnel, 11 km in length, and 11 m and 8 m in width and height, respectively. The thickness of concrete was assumed to be 20 cm to calculate the exposure dose rate of the worker.

As shown in Fig. 1, it was modeled with a radius of 5.5 m and a height of 8 m, and the radioactive source by hydrofluoric acid was a uniform distribution in the concrete. It was assumed to be height of 2 m because the worker sits in a large concrete paved vehicle.

The radioactivity of hydrofluoric acid is conservatively assumed to be 1 Bq/g and the mission time of workers is assumed to be 2704 hours/year.

In the production of accelerating agent using hydrofluoric acid, diethanolamine, phosphorous acid powder, aluminum sulfate and caustic soda are added. At this time, the input ratio of hydrofluoric acid is less than 19% of the total volume. In addition, the mixing ratio of the accelerating agent product to the concrete is 1: 9, so the ratio of hydrofluoric acid to concrete used in the actual tunnel is 1.9% of the total volume.

In addition, the spectrum was calculated using the ORIGEN-ARP [1] module of the SCALE code system to include the effects of daughter radionuclides generated by uranium decay. The ratio of u-234, u-235 and u-238 contained in hydrofluoric acid is assumed to be 0.0054: 0.7204: 99.2742, which is the ratio of natural uranium, and the spectrum used in this calculation is shown in Fig 2.

MCNP6 [2] computer code was used to calculate worker exposure dose and MCPLIB04 was used for nuclear cross-sectional data. The concrete material information used in this calculation is Standard Composition Library [3].

In order to calculate the sensitivity of exposure dose rate according to the length, the distances from 10 m to 11,000 m were classified as shown in Table 1, and the worker was assumed to be in the middle of the tunnel.

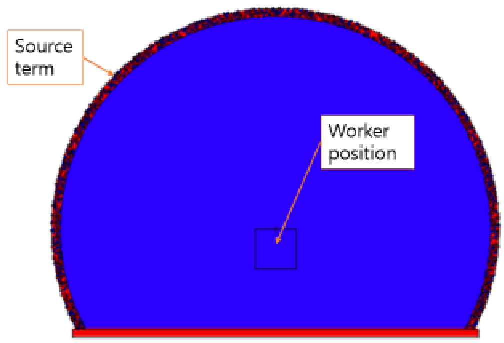

Fig. 1. Modeling of dose rate calculation in tunnel

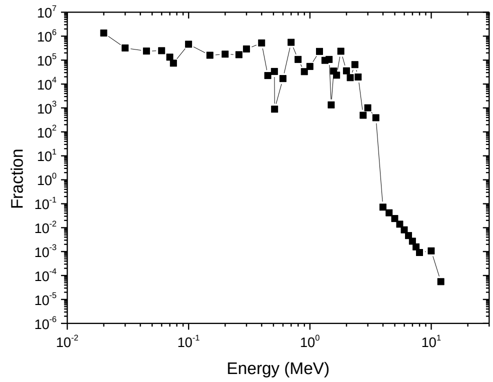

Fig. 2. Spectrum of Natural Uranium

2.2 Results

In shotcrete work for tunnel, the length of the tunnel is assumed from 10 m to 11 km, and the results are shown in Table 1 and Fig 2.

As shown in Fig. 2, when the length of the tunnel is less than 100 m, the radiation dose rate increases rapidly according to the distance. However, when the tunnel length is longer than 100 m, the dose rate tends to be saturated.

Table I: Results of exposure dose rate of worker in tunnel

distance(m)	Dose rate(mSv/h)	Relative Error
10	1.07E-06	0.0038
30	1.59E-06	0.0053
50	1.69E-06	0.0067
70	1.70E-06	0.0056
100	1.73E-06	0.0066
300	1.68E-06	0.0115
500	1.68E-06	0.0149
700	1.70E-06	0.0177
1000	1.70E-06	0.0209
3000	1.78E-06	0.0355
5000	1.59E-06	0.0486
7000	1.68E-06	0.0556
11000	1.61E-06	0.0682

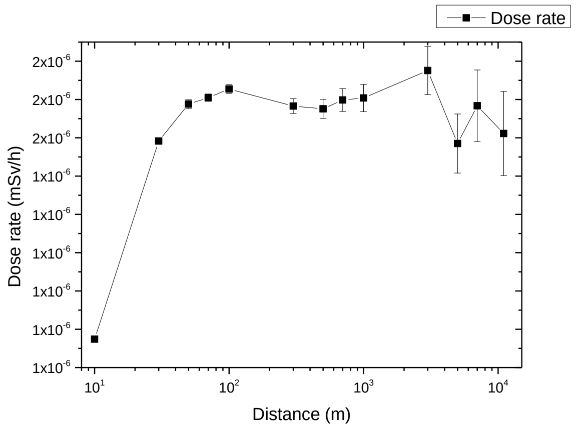

Fig. 3. Modeling of Dose rate in tunnel

3. Conclusions

In this study, we analyzed the sensitivity of the radiation dose rate of workers performing shotcrete work in the tunnel against the modeling length of the tunnel.

As a result, if the tunnel length is more than 100m, the radiation dose rate of workers is evaluated to be similar regardless of the tunnel length. It is considered that the radiation penetrated by the concrete placed in the tunnel has little effect on the workers at the distance of 100m or more, because the energy of most uranium contained in hydrofluoric acid is less than 3.5MeV.

These results show that if the length of the radiation source is long, the radiation dose rate can be estimated by assuming some sections where the influence of the radiation source is large without modeling the whole structure.

REFERENCES

[1] I. C. Gauld, S. M. Bowman, J. E. Horwedel, et al., "ORIGEN-ARP: AUTOMATIC RAPID PROCESSING FOR SPENT FUEL DEPLETION, DECAY, AND SOURCE TERM ANALYSIS," Version 6, Vol. I, Sect. D1, Oak Ridge, USA, 2009

[2] Denise B. Pelowitz, ed., “MCNP6 Usere’s manual Version 1.0,” LA-CP-13-00634, Los Alamos National Laboratory, May 2013.

[3] L. M Petrie, P. B. Fox, and K. Lucius, "Standard Composition Library”, ORNL/TM-2005/39, Oak Ridge National Laboratory, 2009.