Analysis of Off-Site Dose on the Public due to the Discharge of Gaseous Tritium From Wolsong NPPs

Dae-Sun Son*, Jong kuk Lee, Kwan-hee Lee, Sung-il Kim, and Sangmyeon Ahn
Korea Institute of Nuclear Safety, 62, Gwahak-ro, Yuseong-gu, Daejeon, Republic of Korea
*k735sds@kins.re.kr

1. Introduction

Tritium (referred to as H-3) is a radionuclide that is mainly handled in terms of radiation safety management of nuclear power plants (referred to as NPPs) for its high activity. This paper summarizes data of gaseous H-3 from Wolsong NPPs in commercial operation between 2007 and 2016.

KHNP (Korea Hydraulic & Nuclear Power Co.) has operated 6 nuclear power plants in Wolsong site. The type of reactor of Wolsong Unit 1 to 4 is PHWR (Pressurized Heavy Water Reactor), and Shinwolsong Unit 1 and 2 is PWR (Pressurized Water Reactor). The gaseous H-3 that has been discharged from Wolsong NPPs occupied a large portion of the radiation exposure dose to the public. Therefore, it is one of the important concerns for nuclear safety regulation to analyze the radiological hazard of H-3 by evaluating the emission and the dose contribution to the public radiation exposure accordingly.

2. Analysis on discharged H-3 and its dose calculation

2.1 Technical standards and regulatory requirements for radioactive effluents from NPPs

NPPs in commercial operation must be ensured to be operated in compliance with standards and regulatory requirements. It includes environmental protection standards in accordance with relevant law, and technical standards to maintain radiation doses from as low as reasonably achievable (ALARA). Discharge control standard of ventilation on Gaseous H-3 should be under 3.0E+03 Bq/m^3 at the Exclusion Area Boundary (EAB), and annual dose should be lower than 0.25 mSv/year at EAB in the operation of multi-nuclear reactor facilities at one site [1].

2.2 Generation and properties of H-3

H-3 diffuses into the coolant from the damaged fuel cladding after ternary fission of U-235, and is generated by neutron capture of deuterium or (n, α) reaction of Li-6 (^{6}Li (n, α) ^{3}H). H-3 has a half-life of 12.3 years and is converted to a stable nuclide of He-3 by beta decay. The maximum energy of the emitted beta particles is 18.6 keV and the average energy is about 5.7 keV. Since H-3 is a beta-emitting radionuclide with a weak permeation energy, the radiation hazard due to external exposure is negligible, but it is easily absorbed into the human body through oral and skin, which is a major cause of internal exposure.

2.3 Analysis on the emission of gaseous *H-3*

PHWR generates much more H-3 than PWR because it uses heavy water as a coolant which has high probability of H-3 generation due to neutron reaction. Fig. 1 shows the discharged gaseous H-3 from Wolsong NPPs during the last 10 years (2007 to 2016)[2],[3]. Sinwolsong Unit 1 and 2 which are PWRs started operation in 2012, and it is confirmed that the amount of discharged H-3 is much less than in Wolsong Unit 1 to 4, which are PHWRs.

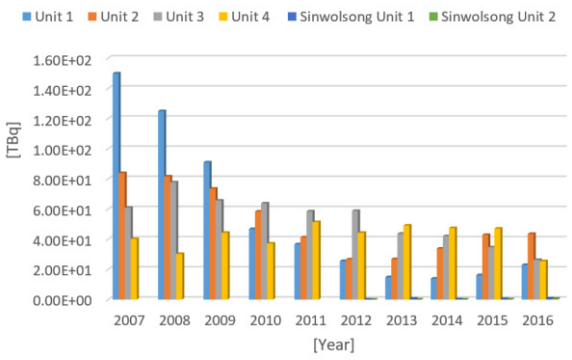

Fig. 1. Amount of discharged gaseous H-3 at Wolsong NPPs per unit.

As part of efforts to reduce the discharge of H-3, KHNP has been operating TRF (Tritium Removal Facility) in Wolsong NPPs since July 2007. As a result, as shown in Fig. 2, the total amount of discharged gaseous H-3 decreased gradually from 3.35E+02 TBq in 2007 to 1.20E+02 TBq in 2016.

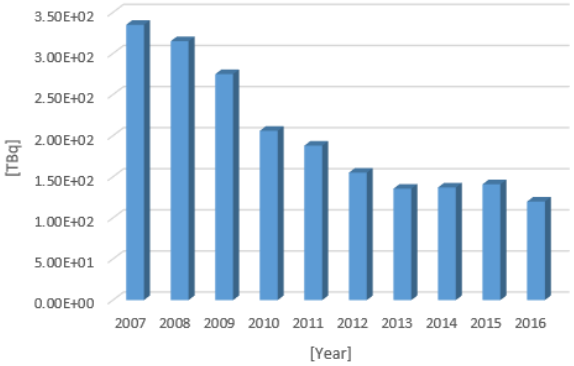

Fig. 2. Total amount of gaseous H-3 discharged from Wolsong NPPs.

2.4 Offsite dose contribution of H-3 to the public

Radioactive gaseous effluents are diffused into the atmosphere first and then they form radioactive clouds and they are deposited on the surface. Thus, the body is exposed externally by the radioactive sources, and internally by respiring the air and digesting intakes of plants and animals contaminated by radioactive materials. The environmental behavior and exposure pathways of gaseous effluents follow the US NRC's Regulatory Guidelines [4], and the concept and system for evaluating the offsite dose conform to the ICRP-60 Recommendation and the IAEA BSS-115. Estimated offsite dose from gaseous H-3 from Wolsong NPPs for the last 10 years (2007 to 2016) is shown in Fig. 3,[5],[6].

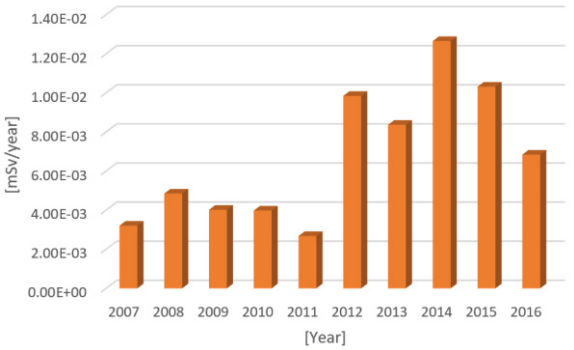

Fig. 3. Estimated offsite dose from gaseous H-3 at Wolsong NPPs.

Although the total gaseous effluents decreased, the offsite dose increased in 2012 more than before. There are a few dominant factors for offsite dose calculation. In this study, change of atmospheric dispersion factor value is one of the major causes of dose increase.

3. Conclusion

In this paper, analysis on discharged gaseous H-3 which is the main radionuclide from the Wolsong site and dose contribution accordingly was conducted during the recent 10 years. Total amount of discharged gaseous H-3 decreased gradually from 3.35E+02 TBq in 2007 to 1.20E+02 TBq in 2016. Although the total gaseous effluents decreased, the offsite dose increased in 2012 more than before. The change of atmospheric dispersion factor value is one of the major causes of dose increase.

4. Acknowledgment

This study is the result of the nuclear safety research project which was funded by the Nuclear Safety Commission and supported by the Korea Nuclear Safety Foundation. (No. 1305004)

REFERENCES

[1] Nuclear Safety Act.
[2] The annual report on the environmental radiological surveillance and assessment around the nuclear facility, KHNP, 2007~2016.
[3] KINS Waste Comprehensive Information Database, 'http://wacid.kins.re.kr'.
[4] US NRC. R.G.1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR PART50, Appendix. I (1977).
[5] ICRP60, Recommendations of the International Commission on Radiological Protection (1990).
[6] IAEA BSS-115, International Basic Safety Standards for Protection Against Ionizing Radiation and for the safety of Radiation Sources (1996).