Statistical Analysis of Radioactive Effluent Data from Korean Pressurized Heavy Water Reactors - 1991 to 2008

Jae Hak Cheong, Kwan Hee Lee, Tae Won Suk, Youn Keun Lee
Korea Institute of Nuclear Safety, 34 Gwahak-ro, Yuseong-gu, Daejeon 305-338, Korea
radwaste@kins.re.kr

1. Introduction

The amount of radioactive materials released to the environment from nuclear power plants (NPPs) is a key indicator to determine the radiological performance of the NPPs. The results of a series of systematic analyses on gaseous and liquid radioactive effluent data from domestic pressurized light water reactors (PWRs) have been reported in 2004. However, specific analysis on the radioactive effluent data from pressurized heavy water reactors (PHWRs) has been rarely reported until recently. In order to demonstrate relative offsite radiological performance of domestic PHWRs, historical radioactive effluent data collected from PHWRs operating in Korea and Canada have been statistically analyzed and compared.

2. Approaches and results

2.1. Acquisition and classification of data

Radioactive effluent data from four units of Korean PHWRs and eighteen units of Canadian PHWRs in the period of 1991 to 2008 were collected and statistically analyzed. The domestic effluent data came from WACID (WAste Comprehensive Information 緝酷腌 base) system which has been operated by KINS and operator's annual report (i.e. Annual Report 昀氈甄攀淤玲 ation Control at NPPs). The information on the amount of radioactive materials released from eighteen units of Canadian PHWRs were collected by extracting the data in the reports published by the Canadian regulatory authority, Atomic Energy Control Board (AECB).

For the purpose of inter-comparison, two target radionuclide groups were chosen for liquid radioactive effluent such as: (1) tritium, and (2) gross beta/gamma or particulate activity. A few radionuclide groups (e.g. dissolved or entrained noble gases and gross alpha activity in liquid effluent) which have been monitored in Korean PHWRs pursuant to applicable regulatory requirements were not used for comparison since they are not reported by Canadian operators. However, carbon-14 in liquid effluent was also excluded in this study due to the fact that the data was only available from Canadian PHWRs. It is noted that most of Canadian operators started to quantify the amount of carbon-14 in liquid effluent around late 1990s, except for Gently 2. On the other hand, five radionuclide groups as (1) tritium, (2) carbon-14, (3) particulate, (4) iodine, and (5) noble gases were selected for inter-comparison of gaseous radioactive effluent data. The radionuclide groups monitored at both Korean and Canadian PHWRs are almost the same.

2.2. Analysis of liquid effluent data

As shown in Fig. 1, the annual average amount of radioactive particulate and tritium in the liquid effluent released from domestic PHWRs varies within the range of 1-order of magnitude. In general, the average tritium release tends to decrease gradually after 1996.

The annual average radioactivity of each nuclide group in liquid effluent released from Canadian PHWRs was compared to that of Korean PHWRs. For tritium, the percent rank of average of Korean PHWRs is top 1% of Canadian PHWRs. However, the average amount of particulate released from Korean PHWRs conforms to top 38% of Canadian PHWRs. Except for the oldest Korean PHWR, WolsonasUnit 1, the annual average of radioactive liquid releases from Korean PHWRs is higher than top 10% of Canadian PHWRs (see Fig. 2).

2.3. Analysis of gaseous effluent data

Fig. 3 shows the annual average radioactive gaseous releases from Korean PHWRs. Both tritium and carbon-14 releases vary within the range of 1-order of magnitude. However, the release data of radioactive particulate and iodines, of which concentrations in gaseous waste streams are easily affected by operating conditions, fluctuate within wider range of 3-order of magnitude. The average release of noble gases tends to

decrease after early 1990s. The apparent increased releases of noble gases and iodines in mid 1990s are ascribed to the fuel defect experienced at Wolsong Unit 1 in 1995 and 1996. It is noted that the amount of tritium in liquid effluent will further decrease along with full-scale operation of the tritium removal facility commissioned in 2007.

The annual average radioactivity of each nuclide group in gaseous release from Korean PHWRs was compared to that of Canadian PHWRs. The average amounts of radioactive particulate, iodines, and carbon-14 released from Korean PHWRs are equivalent to top 3%, 16%, and 24% of Canadian PHWRs, respectively. For tritium and noble gases, however, the percent rank of Korean PHWRs' annual average releases are lower than 50% of Canadian PHWRs. This can be also attributed to the fuel defect in mid 1990s. Except for the oldest Korean PHWR, Wolsong Unit 1, however, the percent rank of annual average of gaseous tritium and noble gases released from Korean PHWRs is higher than top 28% of Canadian PHWRs (see Fig. 4).

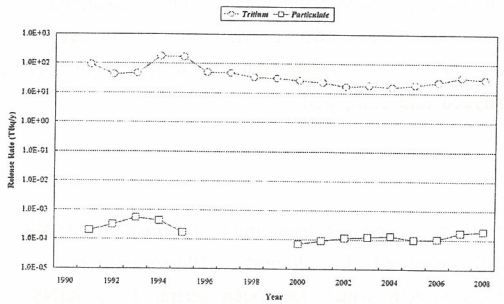

Fig. 1. Annual average liquid radioactive releases from Korean PHWRs (TBq/y per unit)

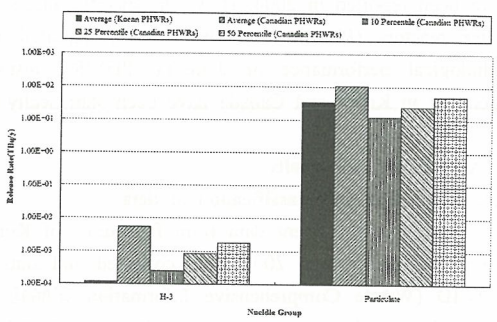

Fig. 2. Comparison of Korean PHWRs' annual average liquid radioactive release data to 10, 25, and 50 percentiles of Canadian PHWRs

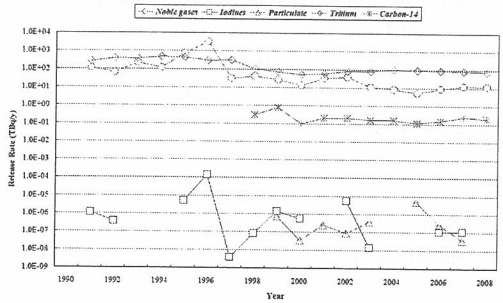

Fig. 3. Annual average gaseous radioactive releases from Korean PHWRs (TBq/y per unit)

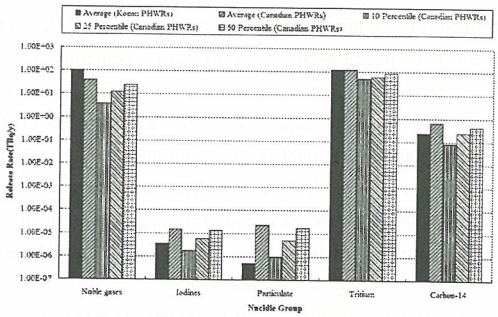

Fig. 4. Comparison of Korean PHWRs' annual average gaseous radioactive release data to 10, 25, and 50 percentiles of Canadian PHWRs

3. Conclusion

As an approach to quantify the offsite radiological performance of domestic PHWRs, historical radioactive effluent data from Canadian PHWRs have been collected and statistically analyzed. It turned out that the average performance of Korean PHWRs' radioactive effluent control is generally better than the average of Canadian PHWRs. The basic approach adopted in this study can be used as an effective tool for deriving an objective barometer to determine domestic PHWRs' environmental sustainability compared to foreign PHWRs.