Comparison of Domestic Nuclear Reactors' Liquid Effluent Data to Foreign PWRs

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1. Introduction

The amount of radioactive materials released from nuclear power plants (NPPs) to the environment can be used as a key parameter to determine radiological performance indicator for public exposure [1]. However, any systematic and/or structural analysis of the domestic nuclear facilities' effluent data has not been reported until recently. In order to quantify relative offsite radiological performance of domestic nuclear power reactors, historical liquid effluent data collected from nuclear reactors operating in Korea, Europe, and the United States have been statistically analyzed.

2. Methods and Results

2.1 Data Sources and Basic Assumptions

Among 19 domestic nuclear reactors, 16 units were selected in this study by excluding Younggwang Units 5, 6 and Ulchin Unit 5 which have very short operating history. In addition, 72 units of the U.S. PWRs and 92 units of European PWRs were selected for the analysis. Effluent data of the selected power reactors were collected from a variety of sources, such as operators' quarterly reports, annual reports, and Bilcom97 database [2].

As the effluent monitoring programs are different country-by-country and rector-by-rector, four target nuclide groups were chosen for more generalized comparison as: (1) fission/activation products, (2) tritium, (3) dissolved gases, and (4) gross alpha.

2.2 Trend of Domestic Reactors' Liquid Effluent Data

The amount of FP&APs (fission and activation products) in the liquid effluent released from domestic NPPs steadily decreased in the period from 1991 to 2001. The more distinctive decrement after 1996 can be attributed to the operators' effluent minimization strategy initiated in the mid 1990's. However, some missed data for the period 1998 to 1999 may result from so-called "zero-release" policy disregarding effluent data below *a-priori* minimum sensitivity requirement for radioactivity measurement (i.e., 1.85E-2 Bq/cc). On average, Ulchin Units 3 and 4 show the best performance, and two of the oldest PWRs Kori Units 1 and 2 released more FP&APs than others due to smaller design capacity of the LRWMS (Liquid Radioactive Waste Management System).

Figure 1 shows the annual average "nuclide group"-specific liquid effluent data of each domestic NPP from 1991 to 2001.

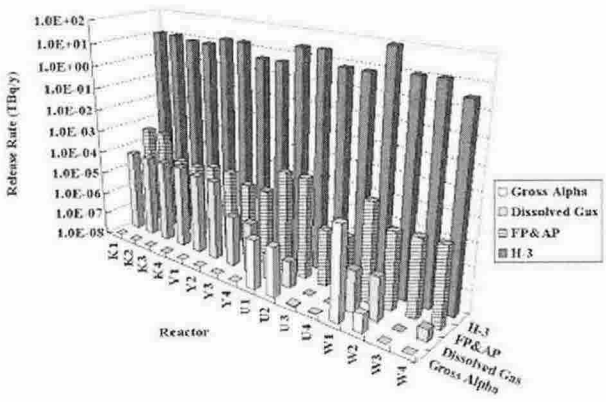

Figure 1. Comparison of domestic NPPs' annual average liquid effluent data (based upon the annual data from 1991 to 2001)

In contrast to the FP&APs, the annual amount of liquid tritium released from each reactor does not vary so much and just fluctuates in the band of 1-order of magnitude. This can be attributed to the fact that tritium exists in the liquid effluent as tritiated water (HTO) and is hardly removed by conventional LRWMS.

The lowest tritium effluent data of Wolsong Units 3 and 4 (PHWRs) is not statistically meaningful due to the very short operation time upto 2001. The highest liquid tritium data for Wolsong Unit 1 reflects its design features and long operating period. However, it is expected that Wolsong Unit 1's tritium release will significantly decrease after operation of TRF (Tritium Removal Facility) to be commissioned in 2005. Among PWRs, relatively new reactors such as Younggwang Units 3, 4 and Ulchin Units 3 and 4 show better performance.

For dissolved noble gases, the released activity also continuously decreased in the period from 1991 to 2001. The decreasing trend can be explained by operators' effluent minimization strategy ensuring sufficient delay/storage time before discharge into the environment. The more frequent detection of dissolved gases at Wolsong reactors may result from the design features of the PHWR's LRWMS adopting not evaporators but simple dimeneralizers and filters.

During the comparison period considered, only very low level of gross alpha activity has been detected in liquid effluent released from Ulchin Units 1, 2, 3 and 4, and Wolsong Units 1 and 2. Due to the limited number of gross alpha effluent data, statistically

meaningful data comparison was impossible. At least, however, the rarely detected gross alpha activity can be attributed to the good performance/integrity of the nuclear fuel and operators' efforts to minimize liquid effluent.

2.3 Comparison to Foreign PWRs' Liquid Effluent Data

Annual average radioactivity of FP&APs in liquid effluent released from worldwide PWRs (i.e., operating PWRs in Korea, European countries, and the United States) was compared to domestic PWRs. The percent ranks of Korean PWRs range from 2.2 to 16.5%, which means each Korean PWR's annual average activity of liquid FP&APs release is lower than 83.5 to 97.8% of foreign PWR units.

Figure 2 shows the annual average liquid effluent data of domestic PWRs along with 25, 50, and 75 percentiles of worldwide PWRs operating in the EU and the United States. The annual average of FP&APs released from domestic PWRs is lower than 25 percentile of the worldwide PWRs.

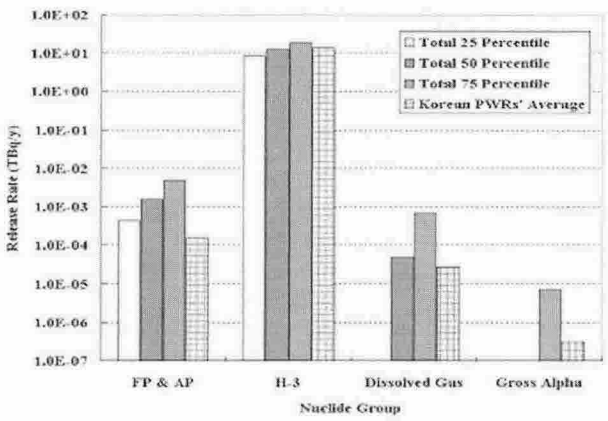

Figure 2. Comparison of domestic PWRs' average liquid effluent data to 25, 50, and 75 percentiles of worldwide PWRs'

For liquid tritium release data, however, the percent ranks of Korean PWRs range from 8.0 to 89.1%. The relatively lower performance (i.e. larger release) of liquid tritium control can be attributed to the refractory characteristics of tritium in the LRWMS. In addition, generally higher capacity factors of domestic PWRs and operating practices of repeated long-term recycling of boron in the primary circuit may also contribute to the result. As shown in Figure 2, the annual average of liquid tritium released from domestic PWRs is comparable to 50 percentile of the worldwide PWRs.

Quantification of noble gases dissolved in the liquid effluent released from PWRs is required in Korea and the United States. However most of the European Union member states' PWRs do not measure noble gas nuclides separately in the liquid effluent. Therefore, noble gas effluent data collected from domestic and American PWRs were compared. The percent ranks of Korean PWRs range from 16.8 to 37.3%. The good performance of domestic reactors can be ascribed to the design characteristics of LRWMS adopting evaporators as main components and operational practices for ensuring sufficient storage time prior to release. In addition, the annual average of noble gases released from domestic PWRs is lower than 50 percentile of the worldwide PWRs (see Figure 2).

For gross alpha activity, the percent ranks of domestic PWRs range from 13.2 to 15.6%.The lower liquid gross alpha activity can be attributed to the good performance of nuclear fuel management at domestic PWRs. The annual average of gross alpha activity released from domestic PWRs is much lower than 75 percentile of the worldwide PWRs.

3. Conclusion

In order to quantify the offsite radiological performance of domestic NPPs, historical liquid effluent data for various western PWRs have been collected and statistically analyzed. The results of this study provide more objective barometer to determine domestic NPPs' environmental sustainability, and show the effective ways to reduce the amount of liquid radioactive materials released to the environment.

REFERENCES

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