Effect of Permanent Shutdown on the Characteristics of Radioactive Effluent Discharges From European and Japanese Nuclear Power Plants

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1. Introduction

Since the provision for notification of the intent of decommissioning was first introduced into the Atomic Energy Act in 1982, the obligation to submit the decommissioning plan was given to the operator in 1995. As detailed items to be stipulated in the decommissioning plan were specified in the Enforcement of the Nuclear Safety Act in 2015, the decommissioning activities have been considered starting from the construction stage [1]. Despite these institutional improvements, most of the nuclear safety standards are mainly specified for construction and operation phases of nuclear power plants rather than post shutdown phase. Since Kori Unit 1 was permanently shutdown and entered the transition phase in June 2017, the need to establish more detailed and specific regulatory guidance for transition and decommission phases has been emphasized.

Detailed safety standards for permanent shutdown phase should be applied to all of the back-end of cycle of NPPs including control of radioactive materials released to the environment in, liquid and gaseous effluents. In addition, there have been no clear provisions on effluent control of radioactive discharges from NPPs decommissioning after permanent shutdown. Therefore, the authors investigate and analyze the characteristics of radioactive effluents released from permanent shutdown NPPs in the world, and suggest implications for effective regulatory control of radioactive effluents after permanent shutdown. In this regard, a case study for the radioactive effluent discharges from a few US NPPs were reported in June 2018 that had been permanently shutdown [2]. In this study, the authors analyzed the characteristics of radioactive effluents of shutdown NPPs in Europe and Japan.

2. Method

Liquid and gaseous radioactive effluent data for European NPPs are provided from radioactive protection publications covering reactor effluent data for each of 1995-1999, 1999-2003 and 2004-2008 in the European Union (Radioactive effluents from nuclear power stations and nuclear fuel reprocessing sites in the European Union, EC-RP-127/143/164). The reports provide radioactive materials emission by nuclide, for NPPs in operation or permanent shutdown. Liquid radioactive effluents are classified into four categories: fission products or activation products, tritium, dissolved gas, and alpha-emitters. In case of gaseous radioactive effluents, it is further categorized into fission products, tritium, radioactive iodine, particulates, and alpha-emitters. In Japan, the liquid radioactive discharge is divided to two categories of radioactive materials except tritium and tritium. The gaseous radioactive discharge is grouped into two categories: radioactive materials except radioactive iodine and radioactive iodine. The effluent data for Japanese NPPs were collected for the period from 1994 to 2016. The effluent data for OBRRIGHEIM and STADE NPPs in Germany and JOSE CABRERA NPP in Spain were analyzed for the period from 1995 to 2008. The authors analyzed effluent data from 2004 to 2008 for BOHUNICE Unit 1 in Slovakia, since the past data are not available in the report. For GENKAI Unit 1 and MIHAMA Unit 1, power generation was stopped in 2011. For MIHAMA Unit 2 and IKATA Unit 1 were stopped in 2012. Table 1 show the permanent shutdown NPPs considered in this study.

Table 1. Shutdown NPPs Analyzed in This Study

Country	Reactor Name	Shutdown Date
JAP	GENKAI-1	27 Apr. 2015
JAP	MIHAMA-1,2	27 Apr. 2015
JAP	IKATA-1	10 May. 2016
DEU	OBRIGHEIM	11 May. 2005
DEU	STADE	01 Nov. 2003
SVK	BOHUNICE-1	30 Apr. 2006
ESP	JOSE CABRERA	30 Apr. 2006

3. Results

3.1 Characteristics of liquid effluent from NPPs in decommissioning

Figure 1 shows the discharge characteristics of liquid effluents from permanently shutdown NPPs in Germany. The amount of fission products or activation products in the liquid radioactive effluent does not tend to decrease after the permanent shutdown. In case of tritium from OBRIHEIM NPP, the emission has been reduced since its permanent shutdown. However, for STADE NPP, the tritium emission has not been decreased after the year of its permanent, 2003, but started to decrease around 2008. Dissolved gas was discharged to a level below the detection limit of both NPPs. JOSE CABRERA NPP in Spain, and does not show a trend of decrease of fission products or activation products in the liquid radioactive effluent after the permanent shutdown. The tritium discharge has been decreased like that for OBRIGHEIM and Japanese NPPs. Both dissolved gas and the alpha-emitters were discharged below the detection limit.

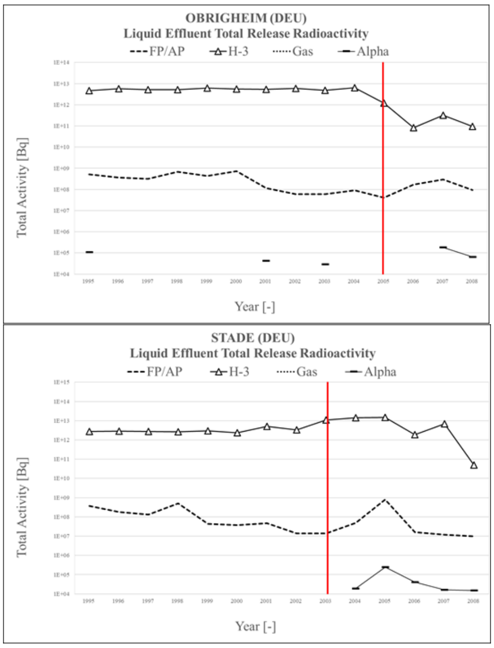

Fig. 1. Total Radioactivity in Liquid Effluent from German NPPs (OBRIGHEIM and STADE) from 1995 to 2008.

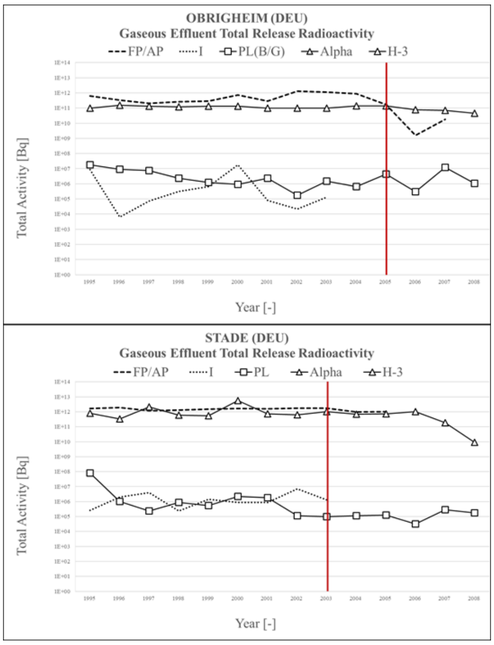

Fig. 2. Total Radioactivity in Gaseous Effluent from German NPPs (OBRIGHEIM and STADE) from 1995 to 2008.

3.2 Characteristics of gaseous effluent from NPPs in decommissioning

Figure 2 shows the discharge characteristics of gaseous radioactive effluents from permanently shutdown NPPs in Germany. Fission products (noble gases) can be seen to remain similar to their past emission data after the permanent shutdown. Unlike tritium in liquid radioactive effluents, gaseous tritium has no significant change in emission after the permanent shutdown. There is no specific correlation between reactor operation and tritium emission. In the case of radioactive iodine and alpha-emitters, there was no specific change in emission even before and after the permanent shutdown. For BOHUNICE NPP in Slovakia, it is difficult to identify any characteristics of the emission pattern before and after the permanent shutdown of a single unit. In JOSE CABRERA, fission products were not detected after the permanent shutdown. In the case of tritium, radioactive iodine and particulates, however, no specific pattern of emission was identified before and after the permanent shutdown. In Japanese NPPs, radioactive iodine did not show a decreasing tendency. In case of except radioactive iodine, however, were discharged below the detection limit.

4. Conclusion

In this study, GENKAI Unit 1, MIHAMA Units 1 and, 2 and IKATA Unit 1 in Japan, OBRIGHEIM and STADE in Germany, BOHUNICE Unit 1 in Slovakia and JOSE CABRERA in Spain were analyzed. Fission products or activation products in the liquid radioactive effluent did not show a decreasing tendency in German and Spanish NPPs.

In case of tritium, however, overall emissions were reduced from all NPPs. In the case of gaseous radioactive effluents, unlike liquid radioactive effluents, tritium discharge did not change significantly after the permanent shutdown. For radioactive iodine, there was no specific emission trend even after the permanent shutdown of both European and Japanese NPPs. The emission was not detected after the permanent shutdown. As a result, the authors identified a difference in the characteristics of the radioactive effluents emitted during the operation of the NPP and after the permanent shutdown. Therefore, it is necessary to study further more specific effluent control plan, and the regulatory requirements for the effluents from NPPs in decommissioning phase.

ACKNOWLEDGEMENT

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