Characteristics of and Implications From Radioactive Discharge Data Before and After Post-Shutdown of Nuclear Power Plants in the United States

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1. Introduction

Nuclear power plants after permanent shutdown no longer use nuclear fuel, so It has a different composition in radioactive effluents than operation phase. US NRC (United States Nuclear Regulatory Commission) Regulatory Guide 1.184 revision 1 provides the regulatory position on decommissioning of nuclear power plants. It is recommended that radiological impacts - including radioactive effluents - should be evaluated for nuclear power plants in transient and decommissioning phase [1]. In addition, the OECD / NEA Radioactivity Characterization and Decommissioning Group has mentioned that during transient phase, nuclear power plants should be assessed for the radiological impacts in performing decommissioning activities caused by radioactive effluents for normal and accidental conditions in its report [2]. In general, the radioactive effluents of a nuclear power plants under operation is monitored at all times by Sampling & Monitoring with radioactivity alarm set points for each radionuclide and in US, it should be reported in the Annual Radioactive Effluents Release Report (ARERR) by 10 CFR 50.36a (a) (2) and Technical specification for each nuclear power plants [3]. This is also valid after permanent shutdown [3]. Before the decommissioning is completed, appropriate monitoring systems should be established to assess the radiological impacts, such as the offsite dose and the radioactivity concentration of the radioactive effluents the that composition is changed by performing the decommissioning activities. In addition, to reduce the risk of activity after a permanent shutdown, the characteristics of the changed radioactive effluents after the permanent shutdown should be identified early. This can be effected as a factor in determining decommissioning activity. In this study presents the implications by analyzing the annual characteristics of the radioactive effluents for the three nuclear power plants which is under the transient/decommissioning phase in US

2. Method

Annual release rate and concentrations and the resulting doses of commercial nuclear power plants in US, can be found in ARERR. In this study, analyzing the characteristics of radioactive effluents before and after the permanent shutdown by using ARERR data of transient/decommissioning phase NPPs and suggesting the implications for decommissioning activities after the permanent shutdown of nuclear power plants perspective in radioactive effluents.

The NPPs to be evaluated are San Onofre Unit 2 & 3, Kewaunee, and Crystal River Unit 3 in the US. The radioactive effluent to be evaluated is the gas and liquid effluent released from NPPs. The evaluation period is from 2006 to all years after the permanent shutdown of each NPPs.

The evaluated subject NPP and its permanent shutdown dates are mentioned in Table 1.

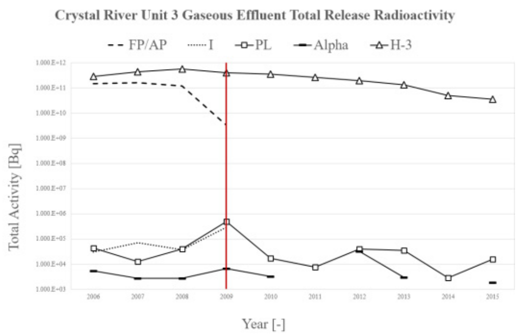
Table 1. Subject Reactor and Shutdown Date

No.	Reactor Name	Unit	Shutdown Date
1	Crystal river	3	2009
2	Kewaunee		2013
3	San Onofre	2&3	2013

3. Results

3.1 Analysis the Aspect of Gaseous Radioactive Effluents of Undergoing Decommissioning NPPs

The gaseous radioactive effluents of the Crystal River Unit 3, Kewaunee and San Onofre Unit 2 & 3 nuclear power plants are plotted in Fig. 1. Tritium emissions are not significantly affected by permanent shutdown, but large amounts are continuously released. However, in the case of Fission Product or Activation Product gas, it is seen that the amount is rapidly decreased due to the fact that the fuel is not irradiated after the permanent shutdown. Particulates gas shows a variety of emission patterns or not emitted after permanent shutdown.



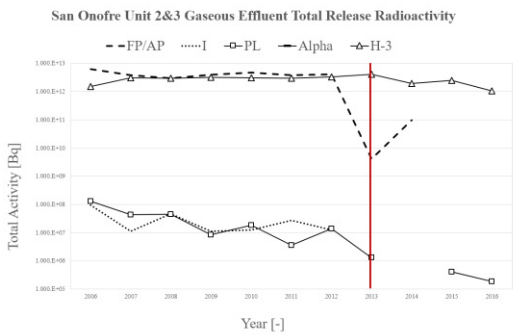


Fig. 1. Total Radioactivity Release Data from 2006 of for Crystal River Unit 3 and San Onofre Unit 2&3 Gaseous Radioactive Effluents.

3.2 Analysis the Aspect of Liquid Radioactive Effluents of Undergoing Decommissioning NPPs

The liquid radioactive effluents of the Crystal River Unit 3, Kewaunee and San Onofre Unit 2 & 3 nuclear power plants are plotted in Fig. 2. Liquid radioactive effluents show more variation than gas effluents. In the case of Tritium, unlike Tritium in gas effluents, emissions continue to decrease after permanent shutdown. The Fission product and Activation product also tends to reduce emissions after a permanent shutdown due to the fact that the fuel is not irradiated.

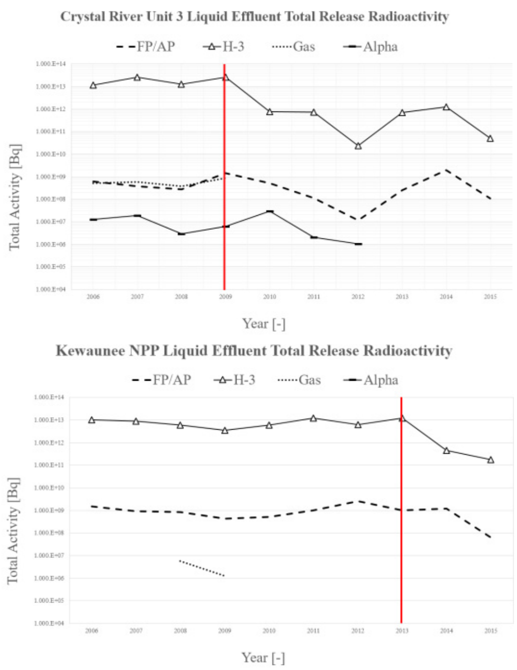


Fig. 2. Total Radioactivity Release Data from 2006 of for Crystal River Unit 3 and Kewaunee Gaseous Radioactive Effluents.

It can be predicted that it will reduce the amount of annual radioactivity release rate of liquid radioactive effluents by for such reasons. Also, it can be expected that the dilution water flow rate for diluting the radioactive effluent will also decrease. As a result of analyzing the flow rate, dilution water flow rate and dilution factor value of the three nuclear power plant, the discharge flow rate of the radioactive effluent decreased after the permanent shutdown. Dilution water flow rate and dilution factor also decreased. There are two reasons why the dilution water flow rate decreases. First, intentional activity can be expected to reduce the dilution water flow in anticipation of a decrease in annual radioactivity emissions of the radioactive effluent. Secondly, it can be expected that the provided dilution water flow rate is reduced. In most cases, the flow rate of the cooling water in the condenser is in charge of the dilution water flow rate. The cooling water in condenser system is decreased by the unnecessary of cooling the system after permanent shutdown. So, the dilution water flow rate can be decreased. Monitoring alarm set point is determined by the value of effluent flow rate and dilution water flow rate. Therefore, the value of the monitoring alarm set point of the radioactive effluent in the NPP during operation may not be able to applicable after the permanent shutdown.

4. Conclusion

In this study, analyzing the annual radioactive effluent trends for three permanent shutdown NPPs (Kewaunee, San Onofre Unit 2 & 3, Crystal River Unit 3) in US. Fission product and Activation product decreases for both gaseous and liquid radioactive effluents. In the case of Tritium, almost constant amount is released regardless of the permanent shutdown in gaseous radioactive effluent. But for liquid radioactive effluents, it shows a decreasing trend, similar with the Fission product and Activation product. The flow rate and the dilution water flow rate of the liquid radioactive effluent decrease after the permanent shutdown. As a result, there is a possibility that the value of the monitoring alarm set point of the radioactive effluent in the NPP during operation is cannot be applicable after the permanent shutdown. Therefore, it may be necessary to establish monitoring alarm settings that take into account the information of the gaseous and liquid radioactive waste management system which is different with the operation phase.

REFERENCE

[1] U.S. NRC, Decommissioning of Nuclear Power Reactors, Regulatory Guide 1.184, Revision 1, October 2013.

[2] OECD/NEA, Ivan Rehak, Radiological Characterisation for Decommissioning of Nuclear Installations, September 2013.

[3] U.S. NRC, Domestic Licensing of Production and Utilization Facility, Code of Federal Regulations Title 10, part 50, 2015.