Efforts to Reduce Radioactive Wastes at High Flux Advanced Neutron Application Reactor (HANARO) in Korea - 9190

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ABSTRACT

The High-flux Advanced Neutron Application Reactor (HANARO) has the equipment to treat the gaseous radioactive waste generated within itself but it does not have proper ways to treat the waste in either a liquid or solid form. For the last 5 years, every effort has been made to reduce the radioactive wastes in HANARO. Improvements of the equipment and operating procedures regarding the generation of radioactive waste in the field have resulted in an effective reduction of the radioactive waste. In addition, as an outgrowth of the research efforts in connection with the demand in the field, several new methods have been developed to effectively treat the radioactive waste. Efforts to reduce and treat the radioactive waste in HANARO will continue and that will contribute greatly to an improvement of the reliability and safety of HANARO.

INTRODUCTION

The High-flux Advanced Neutron Application Reactor (HANARO) is a 30 Mw_{th} multi-purpose research reactor generating high neutron flux (fast flux: 2.1 x 10^{14} $n/cm^2/s$ and thermal flux of 4 x 10^{14} $n/cm^2/s$) at Korea Atomic Energy Research Institute (KAERI). It is the only facility for research and development in the neutron science field and its applications in Korea.

Various types of radioactive wastes are generated from HANARO as well as the other nuclear reactors. The most important property of the radioactive wastes in HANARO is that some radioactive wastes are contaminated with tritium because HANARO uses heavy water as reflector.

At present the radioactive wastewater, spent ion exchange resins and solid wastes generated from HANARO are transferred to and treated/stored in the Radioactive Waste Treatment Facility (RWTF) of KAERI while the radioactive gaseous waste is discharged to the atmosphere through a pre-filter, a High Efficiency Particulate Air (HEPA) filter and a charcoal filter.

However the RWTF does not have proper technology to treat radioactive waste contaminated with tritium from HANARO. Neither does RWTF have enough space to store the waste. Therefore it is imperative to have a proper means to reduce the amount of radioactive waste generated from HANARO and to treat them more safely.

This paper reports the efforts for the last 5 years to reduce, safely handle and treat the radioactive gaseous waste, wastewater, spent ion exchange resins and solid wastes contaminated with tritium generated from HANARO.

RADIOACTIVE GASEOUS WASTE

Radioactive gaseous waste is discharged from the reactor building to the atmosphere through a stack after passing a series of pre-filters, HEPA filters and charcoal filters. Air monitor is installed in the stack to survey the particulate concentration and the radioactivty of iodine, novel gas and tritium in the gaseous waste. The main radioactive nuclides of the gaseous waste are H-3 (tritim), Ar-41 and I-131. Especially, tritium, one of the main nuclides, was the radioacive nuclide of most concern because its discharged activity was increasing from year to year. The specific activity of tritium in the heavy water increases as the operation time of the reactor increases and the specific activity in the discharged air tends to increase in proportion to the operation time in a reactor using heavy water.

In 2005, a part of the heavy water equipment room, which contains pumps to circulate the heavy water, was isolated by an air-tight structure to prevent the tritium from a diffusion. And a tritium removal system was installed to purify the air contaminated with tritium in the stucture. The tritium removal system purifies the air by a condensation and adsorption of the moisture in the air containing tritium.

The annual discharged activity of tritium in the gaseous waste is shown in Fig. 1. The discharged activity of tritium decreased in 2005 and 2006. However, it increased slighly in 2007. It was assumed that a small amount of moisture containing tritium was leaked from the spent ion exchange resins which were being stored in the reactor hall and also the operation time increased over that the period too. The spent ion exchange was tightly sealed and moved into an air-tight structure. After sealing and moving it, it was observed that the activity of tritium in the reactor hall decreased to the level of 1/4 of the initial level. It is expected that the discharged activity of tritium would again decrease in 2008.

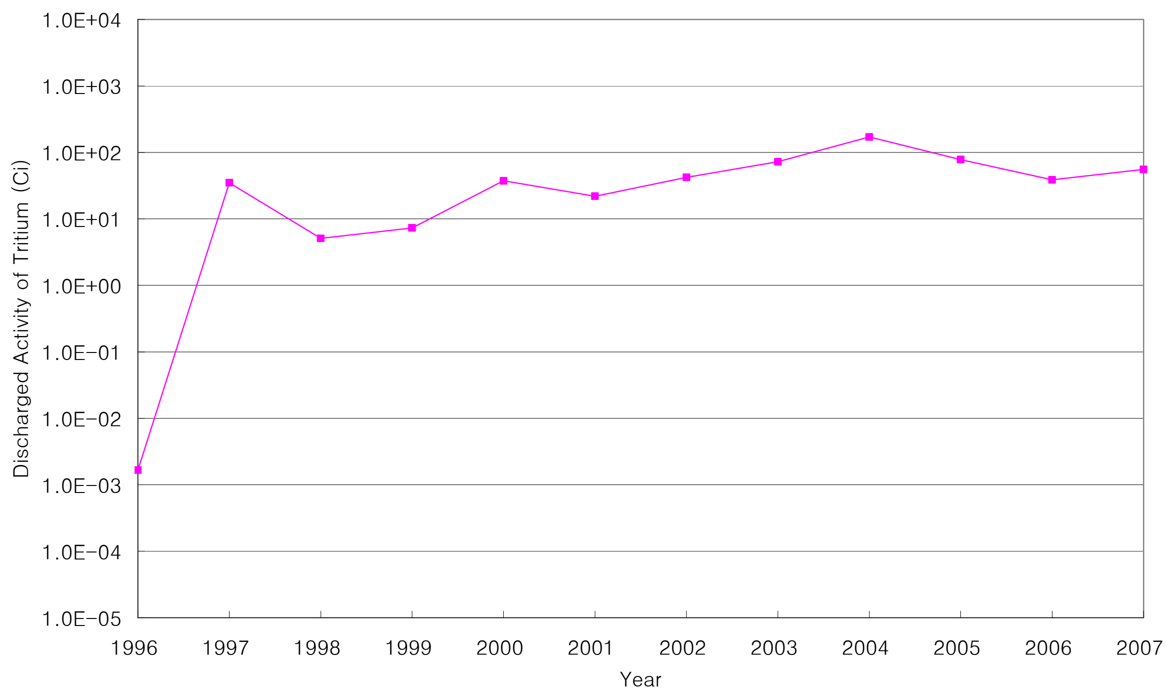

Fig. 1. Annual discharged activity of tritium in the gaseous waste

RADIOACTIVE WASTEWATER

Wastewater with a low level of tritium activity generated from HANARO is transferred to the RWTF. It is naturally vaporized and discharged to the atmosphere in the RWTF. For naturally evaporating the wastewater to the atmosphere, the specific activity of tritium of the wastewater is limited to less than 4×10^7 Bq/m^3. Most of the wastewater generated from HANARO has a level of tritium activity under this limit. Wastewater with specific activity of tritium higher than the limit cannot be transferred to the RWTF.

Radioactive wastewater contaminated with tritium was basically designed to be classified and collected differently according to the level of radioactivity of the tritium. This would be effective in reducing the generation of the radioactive wastewater which cannot be treated in the RWTF due to its high activity. However this rule has been overlooked for the last few years. And sometimes, a wastewater with high level of a tritium activity has been mixed with wastewater with a low level of tritium activity. Although a small amount of wastewater with a high level of tritium activity has been mixed with a relatively large amount of wastewater with a low level of tritium activity, the wastewater with a low level of tritium activity became a wastewater which has too high an activity to be transferred to the RWTF.

Therefore the importance of a classification of wastewater was emphasized and conveyed to the engineers and operators dealing with wastewater. As a result of this effort, mixing between low level wastewater and high level wastewater was prevented in the field and the amount of radioactive wastewater which cannot be transferred to the RWTF was reduced considerably.

In addition, some equipments were developed to evaporate the wastewater with a relatively high level of tritium activity and is being prepared for field tests.

SPENT ION EXCHANGE RESINS

In HANARO, spent ion exchange resins are transferred from an ion exchange bed to a 200L drum. They are properly dewatered before a drumming. At present these drums are stored in HANARO. Surface dose rate of most of them is not high (less than 200 mR/hr). And the drums are going to be stored or solidified in the RWTF.

The most important thing to reduce the amount of spent resins is that the ion exchange beds have a long lifetime. The longer the lifetime of the ion exchange beds, the lesser the amount of spent resins for a certain time.

Ion exchange beds and processes in HANARO have been examined to reduce the amount of radioactive spent ion exchange resins and it was recommended that improvements to the equipment and operating procedures in the field should provided for an effective reduction of the spent ion exchange resins. Thus equipment to fill the ion exchange resins into the ion exchange bed was developed to reduce the spent ion exchange resins because a proper filling of the ion exchange resins into the ion exchange bed can extend the lifetime of the bed. In addition, a drum was developed to easily dewater the spent resins received from the ion exchange beds and safely store then in HANARO or RWTF.

A change of the electric conductivity of the water passing through the ion exchange beds in HANARO from 2004 to 2005 is shown in Fig. 2. It was evaluated that the ion exchange beds didn't exhibit a high enough capability because they didn't maintain a electric conductivity of 0.2 µS/hr of the water for a long time. In 2006, because a proper filling of the ion exchange resins into the ion exchange beds was performed to improve the capability of the ion exchange beds. The change of the electric conductivity of water passing through the ion exchange beds in HANARO from 2006 is shown in Fig. 3. It was observed that the period with an electric conductivity of 0.2 µS/hr of the water was longer than before.

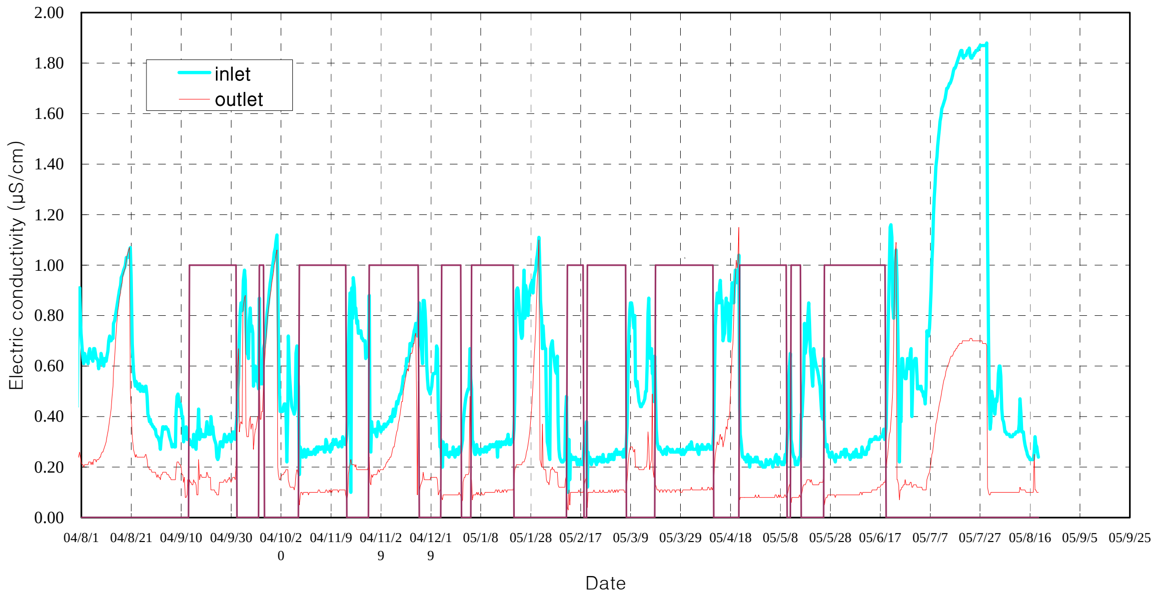

Fig. 2. The change of the electric conductivity of the water passing through the ion exchange beds in HANARO from 2003 to 2005.

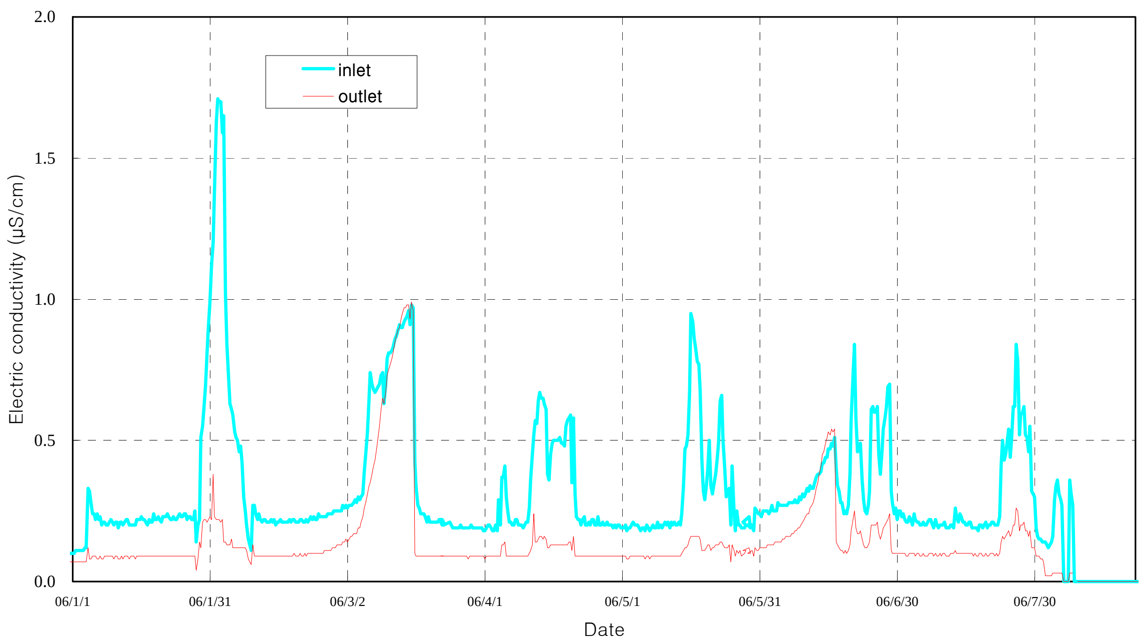

Fig. 3. The change of the electric conductivity of the water passing through the ion exchange beds in HANARO in 2006

RADIOACTIVE SOLID WASTE

From 2005, the following program was prepared and enforced to reduce the radioactive solid waste in HANARO. It was expected that the generation of radioactive solid waste would be reduced.

- Reuse of gowns and clothes by detergent-free cleaning.
- Reuse of non-radioactive waste such as papers, gloves and plastic films by a proper segregation.
- Prevention of mixing of non-radioactive waste and radioactive waste by an inspection and segregation.
- Restriction of equipment, instruments, and tools which are not necessary in radioactive area.

However, the effect of this program could not be quantitatively evaluated because unexpected radioactive solid wastes were generated irregularly due to the construction of new equipment.

SUMMARY

Various attempts have been made to reduce the amount of radioactive waste in HANARO for the last 5 years. And some of them have been adopted and used in HANARO. Efforts to reduce and treat the radioactive waste in HANARO will continue, and they will contribute greatly to an improvement of reliability and safety of HANARO.

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