Decontamination factor Improvement and Waste Reduction of Full-scaled Evaporation System for Liquid Radioactive Waste Treatment

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1. Introduction

Liquid radioactive waste is produced from nuclear power plants, nuclear research centers, radiopharmaceuticals and nuclear fuel fabrication plants, etc [1]. Ion-exchange, chemical precipitation, evaporation, filtration, liquid/solid extraction and centrifugal are applied to treat the liquid waste [2].

Centrifugal system is easy to operate and has low operation cost, but the process has a limitation not capable of treating high concentrated radioactive compounds. Chemical precipitation requires low capital and operation cost. However, it produces large amount of secondary waste and has low DF (decontamination factor). Evaporation process removes variety of radionuclides in high DF. But, it also has problems in scaling and foaming [3, 4].

In this study, it is investigated that the effect of switching lime precipitation and centrifugal processes to evaporation system for improvement of removal efficiency and decrease of waste in full-scaled radioactive wastewater treatment plant.

2. Methods and Results

2.1 The Former Method of Wastewater Treatment

A nuclear fabrication plant produces low concentration radioactive wastewater (LRWW) and high concentration radioactive wastewater (HRWW). In previous system, the LRWW was treated with centrifugal and the HRWW was treated by lime precipitation process separately. If the effluent from these systems has lower radioactive concentration than limitation of discharge (0.08 Bq/mL), it was discharged to wastewater treatment plant outside of the fabrication plant.

2.2 Waste Production

Waste production from the fabrication facility was 1,000 ㎥/yr in volume of wastewater and 15 drums (200L each)/yr in solid waste volume.

2.3 Gross Alpha Analysis

Radioactivity concentration was determined by a gross alpha analyzer equipped with proportional counter detector (FHT 8000A measuring channel/Thermo). Planchet used in the analysis was 60mm and 10mL in diameter and volume, respectively.

2.4 Gamma Radionuclide Analysis

Gamma radionuclide was analyzed by HPGe (High-purity Germanium detector, CCII-VD, CANBERRA) with marinelli beakers (450mL).

2.5 Evaporator (MVR FF 800)

MVR (Mechanical Vapor Recompression) concentrates 5m3 of radioactive wastewater to 100L. It is operated with falling film type heat exchanger in 550~600mbar and 85~93℃ [Fig.1].

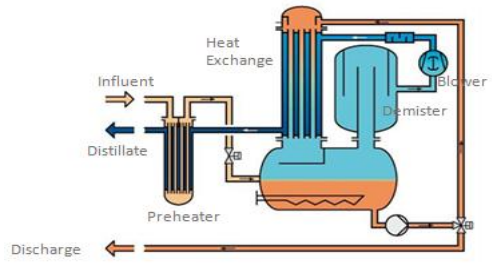

Fig. 1. A scheme of evaporator.

2.6 Crystallizer (DESALT LT 350)

Concentrate from MVR is crystallized by DESALT LT 350. The crystallizer runs in 15~80mbar, 35~38℃. It uses eco-friendly Freon gas as a refrigerant.

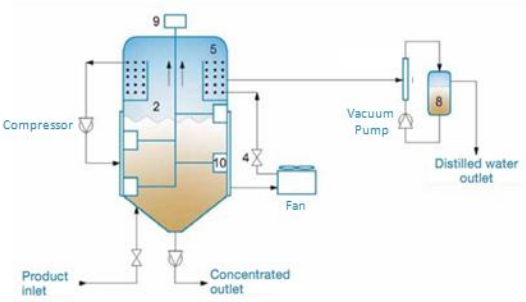

Fig. 2. A scheme of crystallizer.

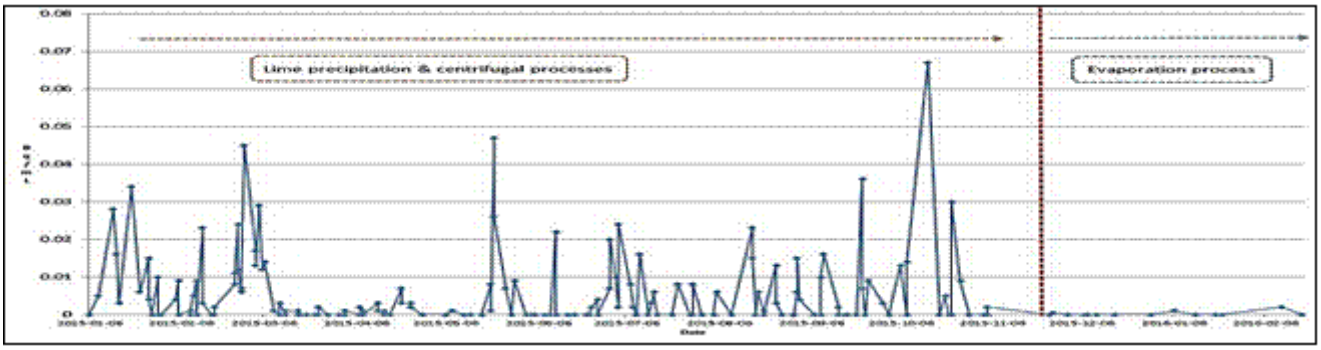

Fig. 3. Improvement of radioactivity decontamination by applying evaporation process.

2.7 Foaming Control

Foaming occurs in evaporator and crystallizer due to the liquid radioactive waste containing high concentration of detergent. Because it causes distillate contamination, both systems inject antifoam using time setting and foaming sensor.

2.8 Decontamination of Radioactivity

Radioactivity concentration of effluent from previous system, centrifugal and lime precipitation was 0.01 Bq/mL. It was necessary to treat effluent again, when the radioactivity concentration of the effluent was higher than the discharge regulation. Although removal of radioactivity was 93%, still traces of radioactive compounds was released to the ecosystem. However, radioactivity was not detected(MDA, Minimum Detectable Activity, α:0.0026 Bq/mL from the effluent of the evaporator and the crystallizer). (Fig 3).

2.8 Waste reduction

Waste production from the former system, centrifugal and lime precipitation, was 15 drums/yr, but that from evaporation process is only 2 drums/yr. Therefore it is possible to reduce waste production significantly (87%).

3. Conclusions

By swapping full-scaled wastewater treatment system from the centrifugal and the lime precipitation to the evaporator and the crystallizer in the nuclear fuel fabrication plant, it was possible to increase removal efficiency and to minimize waste productivity. Radioactivity concentration of effluent is decreased from 0.01 Bq/mL to ND level. Besides, waste production was reduced from 15 drums/yr to 2 drums/yr (87%).

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