Improvement on Liquid Radioactive Waste Treatment System of Nuclear Power Plant By Applying Ion Exchange Method

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1. Introduction

Liquid radioactive waste treatment method of using evaporator was widely used from Kori 1 to Uljin 3&4, but a liquid radioactive waste treatment equipment that uses an ion exchange method instead of an evaporator was adopted aiming to minimize amount of radioactive waste and radiation exposure. However, the same equipment was introduced and applied for the first time in Korea and had experienced difficulties in securing credibility for the equipment and handling of liquid radioactive waste with inadequate data about performance and experience in operation and maintenance. In this study, examination, application and effect analysis was performed on the optimization measure for handling liquid radioactive waste of Yonggwang Nuclear Power Unit 5 and 6(YGN 5&6) that applies an ion exchange method.

2. Methods and Results

2.1 Application of pretreatment method of selective ion exchange system(SIES)

When special liquid radioactive waste or high level radioactive waste are flowed into the Liquid Radioactive Waste Treatment System(LRS), concentration of the processed liquid waste only satisfies design basis value(1.85E-01Bq/cc) of LRS but intermittently can't satisfy plant standard(1.85E-02Bq/cc) of YGN 5&6. Therefore domestic and overseas application cases were studied to improve performance of an ion exchanging equipment through the pretreatment of liquid radioactive waste flowed into LRS, and the pretreatment equipment that is composed with MF(Microfiltration)–RO(Reverse Osmosis) was adopted based on the test results using pilot equipment. It was confirmed that concentration of radioactive material has decreased up to the level of 1/100~1/1000 as the result of conducting performance test by passing liquid radioactive waste that occurred during the plant overhaul period.

Table 1 Test results of the pretreatment equipment

	Raw Water	MF Output	RO Output
TSS*	33	0	0
Activity(Bq/cc)	6.12E+01	3.78E-01	2.48E-01
pH	6.9	6.8	6.1
Conductivity (μs/cm)	574	368	34.5

* Total Suspended Solids

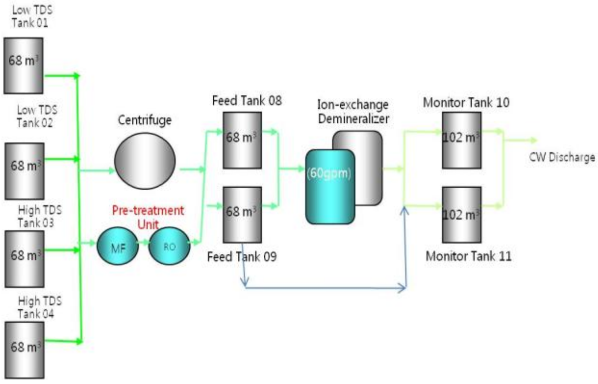

Fig.1 Concept diagram of the pretreatment equipment

2.2 Collection of BAC distilled water

The distillate water occurring during operation of Boric Acid Concentrator(BAC) should be collected with Reactor Makeup Water Tank(RMWT). However, it is transferred to LRS and processed because of high concentration of dissolved oxygen within the distillate water as RMWT limits the concentration of dissolved oxygen to 0.1ppm. This is because fuel cladding can be damaged if BAC distillate water that includes high concentration of dissolved oxygen is collected with RMWT and used as supplementary water for a reactor. However, there is a possibility of operation failure of LRS if the distillate water, which is created about 109 ㎥ per day when BAC is operated consecutively, is flowed into LRS with liquid radioactive waste occurring during normal operation as it exceeds capacity of LRS. In order to solve this problem, installation of a new dissolved oxygen removal equipment was promoted and it was set as that the dissolved oxygen concentration the entrance must satisfy less than 100ppb when the dissolved oxygen concentration of the BAC distillate water flowed based on the design standard is less than 1000ppb. As the result of performance test, when the dissolved oxygen concentration of the flowed BAC distillate water is 209ppm then the dissolved oxygen concentration of the effluent measured by consecutively operating the dissolved oxygen removal equipment for 3hours 20minutes satisfied the design standard with less than 20ppb. According to the operation data, operation days of BAC per 1Rx-year is about 22days and the demineralized water cost of production is about 3,000 won per 1ton based on 2008, so about 10 million won(109 ㎥/day × 22day/Rx-yr × 3800won/㎥) of cost can be reduced with reuse through collection of the distillate water. Moreover, operation hours of LRS are reduced to about 11days per 1Rx-year since the optimal handling amount of LRS is 9ton/hr.

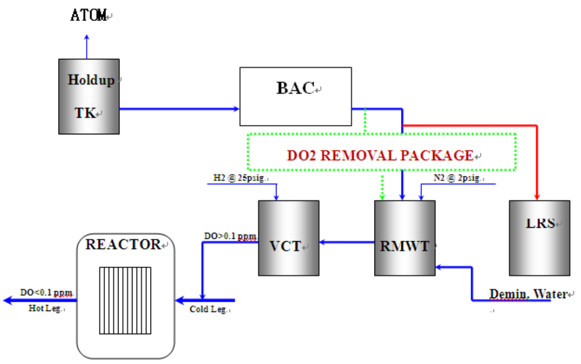

Fig.2 Schematic diagram of the dissolved oxygen removal equipment

2.3 Collection of boric Acid waste

Cooling water remaining in the bottom of tank or the pipe located under the pump at the time of drainage for maintenance operation at the primary cooling water that contains the boric acid water can't be collected to the collection tank and drained to the floor of building, so it is increasing amount of liquid radioactive waste. Moreover, with characteristic of RO membrane, waste including boric acid of high concentration over 1000 ppm increases load of LRS as process efficient decreases due to occurrence of high pressure difference. Therefore the boric acid water was collected with Refueling Water Tank(RWT) by developing a 3D drawing program using AUTO CAD and a compulsory drainage method through compression air pressurizing in order to collect boric acid waste that is disposed. The biggest effect by applying this method is reduction of drainage time. The drainage time was reduced about 9hours compared to before as the result of conducting a verification test targeting safety injection system and containment spray system during the overhaul. This can bring out about 700 million won(1,000,000kWh × 9hr × 2train × 40won /kWh) of financial effect with reduction of overhaul period as it arouses increase of electric power generation when it is main process.

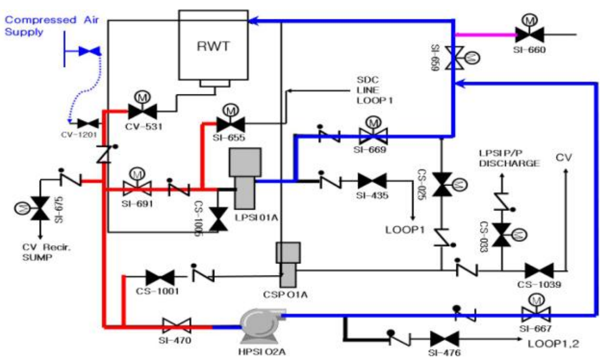

Fig.3 Collection method of boric acid waste

3. Conclusions

Effects according to improvement of the liquid radioactive waste handling method were analyzed as follows.

First, LRDPS filling exchange volume had decreased after installing the pretreatment equipment. If it is converted into 200 ℓ waste drum, it is as follows.

Table 2 LRDPS filling exchange status

Year	Exchange volume (ℓ)	Number of 200ℓ drum
2004	18420	92.1
2005	6200	31.0
2006	24242	121.2
2007*	18138	90.7
2008	4478	22.4
2009	9600	48.0

* Installation of the pretreatment equipment

In other words, the annual average number of drums from 2004 to 2006 were 81.4 before installing the pre-treatment equipment and the annual average number of drums from 2007 to 2009 were 52.7 after installing the pretreatment equipment so about 30 drums are reduced yearly.

Second, installation of the dissolved oxygen removal equipment to collect BAC distillate water to RMWT and to reuse it can reduce about 10 million of demineralized water supplementary cost per 1 Rx-year(based on 1 unit).

Third, if boric acid is collected by applying the 3D drawing program and the compulsory draining method then more than about 700 million won of financial benefits can be gained through reduction of drainage time when the relevant operation is the main process of the maintenance period.

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