Development of Movable Apparatus for Radioactive Noble Gases Removing

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1. Introduction

Many people who work for maintaining Nuclear Power Plant perform their tasks in slight air-pollution environment for planed preventing maintenance period. To secure the technique which is removing this medium · low level radioactive noble gases is the technique related making removing device which is used in right time and position and is possible to be moved. Also, it remove the radioactive noble gases which are in the high level compartment when low volume air circulation facility of the building is not able to remove them during planed preventing maintenance period by nuclear fuel fault etc. Therefore, it can be prevents air-pollution and minimizes radiation exposure of the maintenance people by removing the pollution before the performing planed maintaining tasks.

2. Methods and Results

This device consists of Moisture Removing device and CO_2 Removing Trap, Radioactive Noble gases trap, Cooler for Removing trap, Measuring Module for temperature · humidity, CO_2 concentration and air flow, Data maintenance system and GC(PDD) for measuring concentration of radioactive noble gases. The Adsorption and the Cryogenic Freezing Methods are used for removing radioactive noble gases.

2.1 Moisture Removing Device

The excess moisture in polluted air has to be removed because it disturbs removing radioactive noble gases. It consists of first device and second device. The first moisture removing device was made for removing excess moisture by dehumidifying device using refrigerant heat exchanger[1,2]. The result for efficiency test is table 1.

$$RH = \frac{\rho_{(H_2O)}}{\rho^{*}_{(H_2O)}} \times 100 \quad (1) \qquad \rho_{(H_2O)} = \frac{RH \times \rho^{*}_{(H_2O)}}{100} \quad (2)$$

RH : Relative Humidity for Specific Temperature (%)
$\rho_{(H_2O)}$: H_2O Vapor Amount for Specific Temperature, g/m^3
$\rho^{*}_{(H_2O)}$: Saturated H_2O Vapor Amount for Specific Temperature, g/m^3

$$\text{Removing Moisture Rate}(\%) = \frac{\text{Moisture Amount of Suction Air} - \text{Moisture Amount of Discharge Air}}{\text{Moisture Amount of Suction Air}} \times 100 \quad (3)$$

Table 1: The result for efficiency test of the first moisture removing device

Sorting		First	Second	Third
Experiment Time(Hour)		8	8	8
Suction Flow Rate(m^3/h)		112.77	113.90	115.08
Average of Suction Air	Temperature(℃)	33.93	33.32	33.79
	Humidity(RH%)	100.00	100.00	100.00
	Moisture content (kg)	33.17	32.22	33.12
Average of Discharge Air	Temperature(℃)	10.39	9.94	9.14
	Humidity(RH%)	98.76	99.65	100.00
	Moisture content(kg)	8.43	8.38	8.10
Average of Removing Moisture Rate(%)		74.57	73.99	75.53

The second moisture removing device was made by adsorption type using an absorbent (Molecular Sieve 4A) and multistage structure which is changing the absorbent amount actively according to the moisture amount passed from the first device, installed screen[3]. The result for efficiency test is table 2.

Table 2: The result for efficiency test of the second moisture removing device

Sorting		First	Second	Third
Experiment Time(Hour)		8	8	8
Suction Flow Rate(m^3/h)		112.77	113.90	115.08
Average of Suction Air	Temperature(℃)	10.39	9.94	9.14
	Humidity(RH%)	98.76	99.65	100.00
	Moisture content (kg)	8.43	8.38	8.10
Average of Discharge Air	Temperature(℃)	23.70	23.56	21.99
	Humidity(RH%)	28.64	27.15	32.94
	Moisture content(kg)	8.43	8.38	8.10
Average of Removing Moisture Rate(%)		3.96	4.20	4.16

2.2 CO_2 Removing Trap

The CO_2 in polluted air has to be removed because it disturbs removing radioactive noble gases. It is made by using an absorbent (Sodalime), and by a multistage structure which is changing the absorbent amount actively, installed screen as the Second moisture removing device[3]. The result for efficient test is table 3.

$$\text{Removing } CO_2 \text{ Rate}(\%) = \frac{CO_2 \text{ Conc} \cdot \text{of Suction Air} - CO_2 \text{ Conc} \cdot \text{of Discharge Air}}{CO_2 \text{ Conc} \cdot \text{of Suction Air}} \times 100 \quad (4)$$

Table 3: The result for efficiency test of the CO_2 removing trap

Sorting		First	Second	Third
Experiment Time(Hour)		8	8	8
Suction Flow Rate(m^3/h)		112.77	113.90	115.08
Average of Suction Air	Temperature(℃)	10.39	9.94	9.14
	CO_2 Conc.(ppm)	419.81	431.47	431.33
	Total Suction Amount of CO_2(kg)	0.724	0.752	0.761
Average of Discharge Air	Temperature(℃)	23.68	23.56	21.99
	CO_2 Conc.(ppm)	62.64	183.03	65.17
	Total Discharge Amount of CO_2(kg)	0.102	0.302	0.108
Average of Removing CO_2 Rate(%)		85.06	57.04	84.86

2.3 Radioactive Noble gases Removing trap and Cooler

Radioactive Noble Gases Removing Tarp consists of the first device and the second device in order to increase removing efficient. Each of these traps has the same structure and the inside volume of them is designed considered the noble gases amount which is reacted enough with the absorbent. Also, it is made by gastight structure with installing inside structure (Disk) in order to increase the retention time of the noble gas in the absorbent. And it is installed by the sample port for checking the adsorbent temperature change and the measurement of the removing noble gases rate. The absorbent in the trap is Activated Carbon, and the cooler for the trap uses a liquid nitrogen auto-supplying device[3,4,5].

The removing radioactive noble gas experiment was progressed with using non-radioactive Xe gas in a laboratory size. We supplied Xe 5ppm(Supplying it by diluting 10% Xe(He Balance) with suction flow) which is over 55times more than in general air (0.09ppm) to the trap for 8hour and then we analyzed 10 times the Xe concentration in discharged air from the outlet of the first and the second trap.

2.4 GC-PDD System for microanalysis of Xe

We use iGC7200 GC(DS SCIENCE INC.), PDD(VICI) Detector, Gas Sampling Valve and HayeSep D Column for Xe analysis.

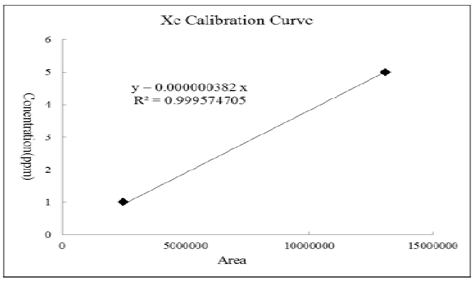

Figure 1. Xe Calibration Curve

2.5 Xe Removing Rate in the outlet air exhausted from the first and second trap

Average Flow Rate of the Suction Air:

30 m^3/hr(0.5 m^3/min)

Xe Conc. of the Discharge Air Formular:

$y=0.000000382x$, $R^2=0.9996$

Table 4: Xe removing rate of the first and second radioactive noble gases removing trap

Sampling Frequency	1	2	3	4	5	6	7
Removing Rate of Xe	98.66	97.58	94.84	96.08	98.18	94.61	96.42
Sampling Frequency	8	9	10	11	12	13	
Removing Rate of Xe	96.61	99>	99>	97.24	99>	99>	

3. Conclusions

As the result, the Removing Xe Rate(%) is over 90%, but it is limited by low flow rate which is the 30 m^3/h(0.5 m^3/min) average flow rate. When the average suction flow increase to 120 m^3/h(2 m^3/min), the Xe is detected directly at the outlet of the first and the second radioactive noble gas removing trap. Because the Xe retention time declined rapidly by increasing the inside absorbent temperature rapidly by the high-temperature air (About 20℃ ~ 25℃) which is discharged from the end of CO_2 removing trap.

In order to complement above problem, it is needed to supplement Preliminary Cooler on the end of the CO_2 removing trap. Through above result, we found enough the possibility for making the Small Movable Apparatus for Removing Radioactive Noble Gases, and if we resolve the problem, it will be anticipate to use in the real field usefully.

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