A Study on the Purification of Water-Pool in Irradiated Materials Examination Facility

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ABSTRACT

The pool (3mx6mx10m) in Irradiated Materials Examination Facility is generally used to transport irradiated materials between a moving cask and hot-cell. During the operation in the pool such as loading/unloading the cask, holding specimen and bucket elevation, water maybe contaminated by radioactive or contaminated impurities from irradiated materials. Then, it must be purified and filtered continuously to keep lower radioactivity than that of regulation prescribed by RCA Korea Activity in a part of radioactive contamination control. This paper described radioactive contamination distribution of water as transported materials, which is related to effective operation of purification and filtration system.

I. INTRODUCTION

Generally, irradiated materials including nuclear fuels must be contained in cask for transportation. For inspection, these irradiated materials are moved to hot-cell in IMEF(Irradiated Materials Examination Facility). The cask is opened under water to protect neutron and diffusion of contamination.

The pool in IMEF was built with Stainless Steel 304L lining and thickness of structure was designed with assumption that nuclear fuel with 106 Ci of 1 MeV gamma rays should be shielded below 9.0×10-6 Sv/hr.

200 m^3 of water in the pool circulates by 1 cycle for 72 hours with flow rate(16 m^3/hr) of pump. Filter and ion-exchange resin were installed to keep radioactivity of water by below 10-4 μ Ci/cc. Exchange device for filter and ion-exchange resin was added to purification system. Also, the shielding cover was set up to protect radiation from the contaminated filter and the ion exchange resin. During the operation of cask into the pool, water must be cleared due to visual work. So, turbidity of water must be kept below 3 NTU by filtering impure particles(> 6 μm). In addition, water is preserved with condition of 5 μS/cm of conductivity and 5 < pH < 8. Radiation dose rate of circumference and water level should be kept below 15 mR/hr and more than 8.30m of depth, respectively.

II. EXPERIMENTAL

Purification system was placed in the basement. Two pipe lines(4 inches of dia.),which are in-let and out-let, were connected between bottom of pool and Purification system. Skimmer was installed to in-let line as well. Diagram of this system is shown in fig.1. Equipments in this system are as follows;

- Pre-filter and pre-filter housing :

4 pre-filters in the housing remove large particles (>40 μm) from water.

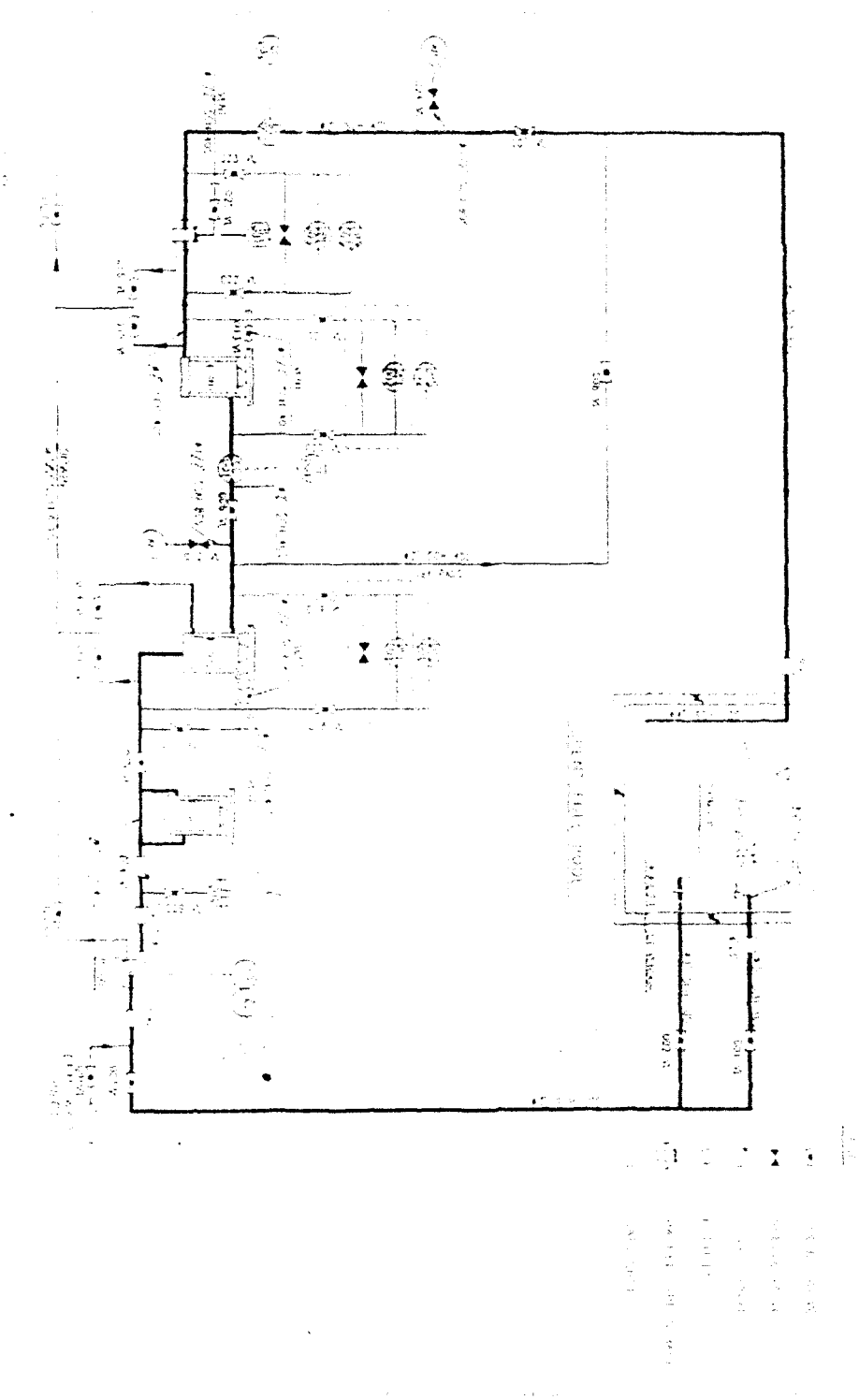

Fig. 1. Schematic diagram of Water-Purification system in the pool.

- Filter (F-002) and filter housing

This filter removes small particles (>6 μm) from water.

- Ion exchanger and resin cartridge (E-001)

This equipment removes radioactive ion particles by resin.

Besides, conductivity cell and indicator, DPS & DPA, control panel, shielding wall, pump & motor, basket strainer, piping system, valves & gauges and a filter & Ion-exchanger cartridge handling tool were equipped.

There are two filtration methods for purification. One is normal operation that water circulates via pre-filters and filter(F-002) to remove impurity particles. The other is that water circulates via not filters but ion-exchanger to remove radioactive ion if pool seems to be contaminated. Resin used in ion exchanger is useful to remove both negative and positive ions.

III. RESULTS AND DISCUSSION

Radioactivity and quality of water in the pool had been measured from January, 2002 to August, 2003. Table. 1 shows the radioactive contamination distribution level chart with respect to each cask work in the pool. In Fig. 2, α-contamination level was low steadily but several peaks of β-contamination level were observed during a month after transportation of monitoring capsule. In this time, radioactivities of CO-60 and Cs-137 were remarkably high due to transportation of DUPIC nuclear fuel rig in October 8, 2002 as shown fig. 3.

Table. 1 Radioactive contamination distribution level chart about irradiated material and fuel of each specimens

Date (in)	Kinds of carried-in specimen	Contamination level (Bq/mL)		Dose rate (Bq/mL±2σ)		Turbidity (NTU)	Conductivity (μg/cm)	pH
		A-Corrected	β-Corrected	Co-60	Cs-134			
'02. 2. 5	DUPIC HANARO fuel	-	1.2E-04					
'02. 3.26	Surveillance capsule (YK3-1)	4.7E-05	2.4E-02					
'02. 4.29	Surveillance capsule (YK 3)	6.8E-03	2.2E-01					
'02. 5. 9	Pool water of chemical analysis trust	<2.00E-02	<4.00E-02	<5.32E-03	<5.25E-03	<0.5	4.0	6.03
'02. 6.12	Irradiated examinated specimens carried-out (twice)	1.9E-03	6.1E-02					
'02. 9. 5	Pool water of chemical analysis trust	1.03E-02±0.003	9.22E-02±0.009	<9.39E-03	<5.82E-03	<0.5	3.72	5.95
'02. 10.8	DUPIC fuel rig. carring-in	5.7E-03	9.2E-02					
'02. 11.8	Pool water of chemical analysis trust	7.62E-03±36.6%	3.57E-01±4.8%	<1.51E-02	<3.90E-03	<0.5	3.7	5.47
'02.11.14	Steam generator(YK) and Monitoring capsule	7.1E-03	3.2E-01					
'02.11.19	HANARO fuel for the licence/permition	1.4E-04	1.2E-03					
'02.11.22	Surveillance capsule (YK 4-1)	8.9E-04	7.3E-03					
'03. 1.8	Surveillance capsule (UJ 2-4)	8.1E-03	5.8E-01					
'03. 1.9	Pool water of chemical analysis trust	<1.2E-02	<5.0E-01	5.01E-02±8.5%	<6.62E-03	<0.5	3.99	5.68
'03. 3.11	Instrumented capsule (01M-05U)	1.9E-04	1.3E-03					
'03. 4.30	Pool water of chemical analysis trust	<3.0E-02	<5.0E-02	<6.20E-03	<3.24E-03	<0.5	5.31	5.84
'03. 5.20	Surveillance capsule (KR 4-5)	1.1E-03	2.1E-02					
'03. 6.10	Pool water of chemical analysis trust	<3.0E-02	<5.0E-02	<1.25E-02	<5.43E-03	<0.5	1.66	5.85
'03. 7.29	Pool water of chemical analysis trust	<3.0E-02	<5.0E-02	<5.09E-03	<5.70E-03	<0.5	1.03	5.58
'03. 8.12	Instrumented capsule (02M-05U)	<6.14E-04	<8.2E-13					
'03. 9.3	Pool water of chemical analysis trust	<3.0E-02	<5.0E-02	<6.19E-03	<5.11E-03	<0.5	1.38	5.88
'03.10.22	Pool water of chemical analysis trust	<3.0E-02	<5.0E-02	<2.88E-03	<4.35E-03	<0.5	1.12	5.57
'03.11.6	Irradiated capsule in HANARO (01S-01C, 02F-11K)	<2.06E-04	<3.1E-03					
'03.12.5	Irradiated capsule in HANARO (01S-01C, 02F-11K)	<4.00E-02	<6.00E-02	<3.64E-03	<4.36E-03	<0.5	1.94	5.89

Turbidity in fig. 4 shows nothing change. As shown pH values in fig. 5 and electrical conductivity in fig. 6, high peaks were observed at first in the same period. It is based on the transportation of Young-Kwang 4 monitoring capsule in April 29, 2002 and instrumented capsule in March, 2003. After two capsule works, water in pool was acidified gradually.

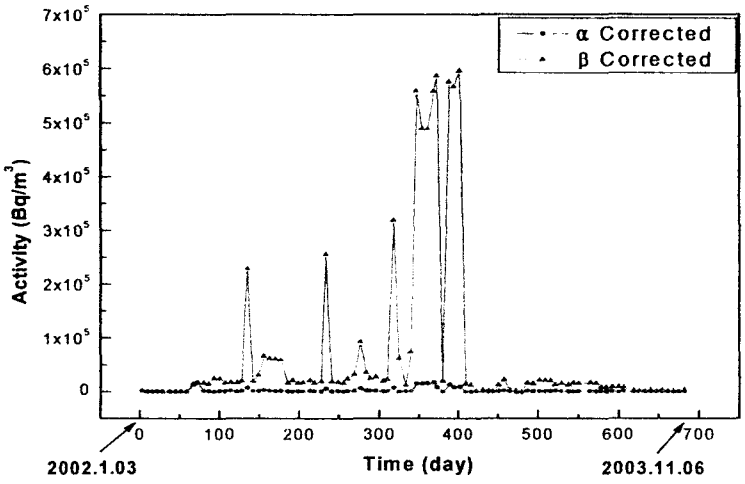

Fig. 2. Activities of α-Corrected and β-Corrected.

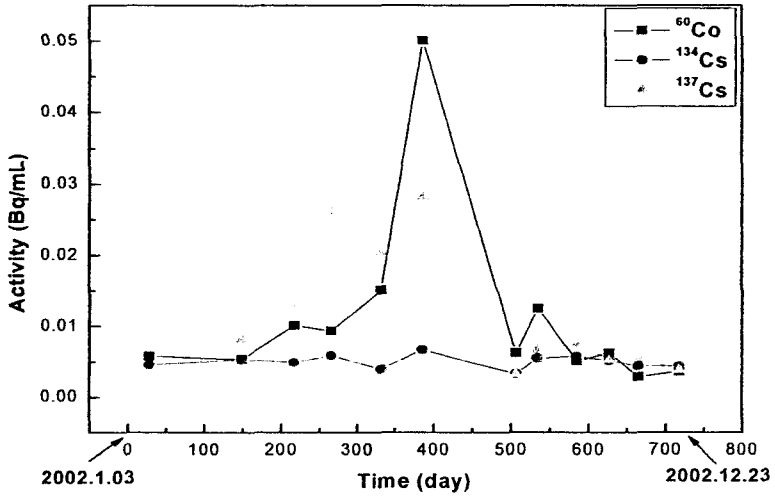

Fig. 3. Radioactivities of Co-60, Cs-137 and Cs-134.

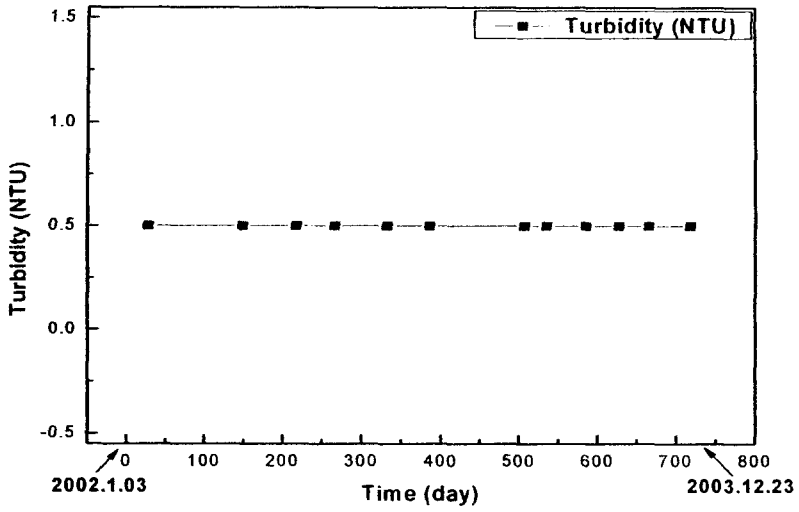

Fig 4. Turbidity (NTU).

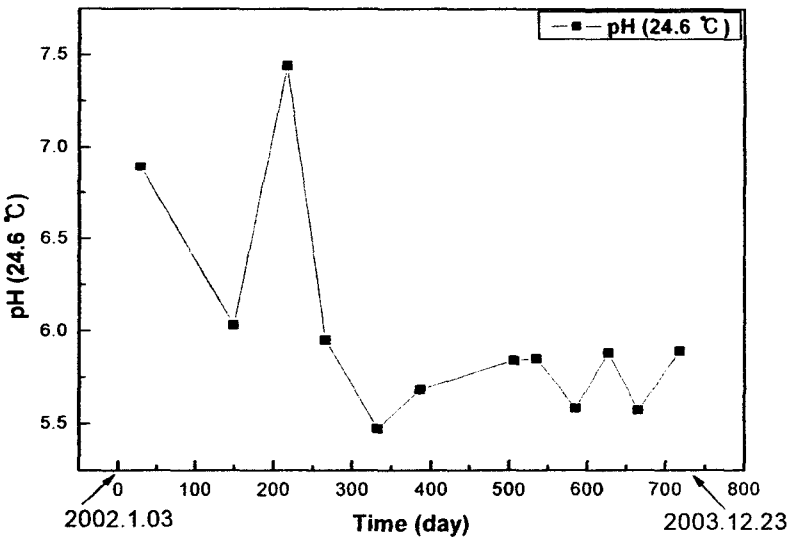

Fig 5. Distribution of pH (24.6 ℃).

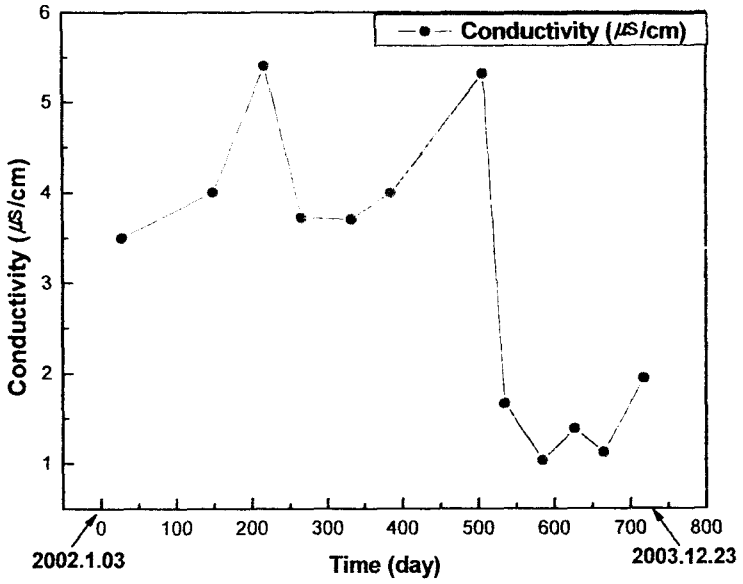

Fig 6. Electric conductivity (μS/cm).

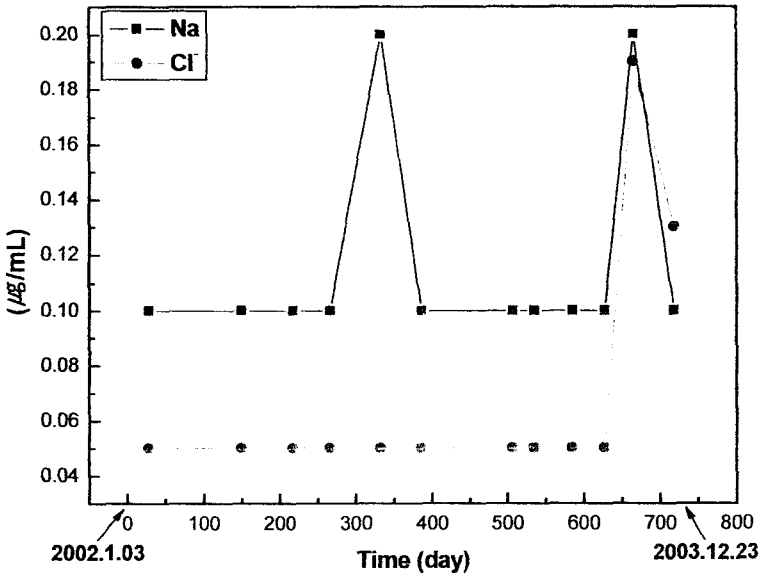

Fig. 7. Concentration of Na and Cl (μg/mℓ).

IV. CONCLUSION

Radioactivity contamination level of water in the pool during 2 years has not been increased and kept below regulation continuously. Several high peaks were shown but decrease after change of filter and purification with ion exchanger. Turbidity is able to be low with only filtration. If radioactive contamination of water is not severe, normal filtration after purification with ion exchange resin for 1 week should be effective. It is concluded that filter must be often changed (up to 4kg/㎠) and purification system is operated for 8 hours in a day at least. Also, it is important that control of pH and electric conductivity.