Multi-nuclide Removal Equipment

Increase in radioactivity level of outlet water in System B

March 24, 2014

Tokyo Electric Power Company

東京電力
TEPCO

Root Cause Investigation and Start of Purification Operation

Probable cause

- The cause is estimated that carbonate containing much Sr which had passed though the crossflow filter ("CFF") due to its malfunctioning remained in the absorption tower, etc., and was slowly flowed out and resolved at the neutrality zone, which eventually reached at the exit of System B of the multi-nuclide removal equipment, where an increase in radioactivity (gross β) in water was identified.

Start up of purification operation with Systems A & C

＊In parallel with addressing the root cause investigation on the flaw of the CFF and the decontamination and recovery of System B, actions to purify the transportation system using Systems A and C have been taken since March 24 after implementing preventive measures to suppress the radiation level of outlet water and avoid spreading contamination to treated water tank.

＊It is planned to suspend the operation of System A for one week or so to replace the absorbent and clean up the CFF with acid. (Planned duration: about 10 days)

＜Actions to be taken ＞

- Replacement of absorbent (1A, 2A, and 4A),
- Acid cleaning of the CFF, and
- Check on Back-pulse pot (Improvement of reliability by replacing the existing one with a new type one)

Policies on Probable Factor Evaluation and Root Cause Investigation (1/2)

■ Probable factors of the radiodensity of gross beta identified at high level caused by Sr*1 are as follows:

Probable factor analysis

	Factor 1	Factor 2	Verification method	Result	Status
Increase in radiodensity of gross beta in outlet water of System B.	Poor performance of Sr Absorption towers (no. with 3 to 5) .	Error in opening/closing of valves.	Line-up check.	×	No errors found to be existed in line-up.
		Sheet-pass of valves.	Evaluation on radiation dose increase.	×	Since a large amount of gross β was detected, accordingly a minor leakage would be hardly to occur with sheet-pass made of pulp, etc.
		Breakthrough of adsorbent 2 (removal of Sr).	Confirmation on the timing of replacement.	×	Capacity of removal was adequate as the first absorbent of Sr removal tower (Absorption tower 4B) had been just replaced (Mar. 12).
	Poor performance of pre-treatment (carbonate coprecipitation)*2.	Poor performance due to insufficient chemical injection.	Confirmation of performance of the exit part of pre-treatment	×	No significant transition was observed in the performance quality at the exit part of pre-treatment.
		Carbonate which went through CFF3B remained in the absorption tower and in the pipes.	Visual check of the inside/ Check of radiation dose of cleaning detergent	△	Under investigation

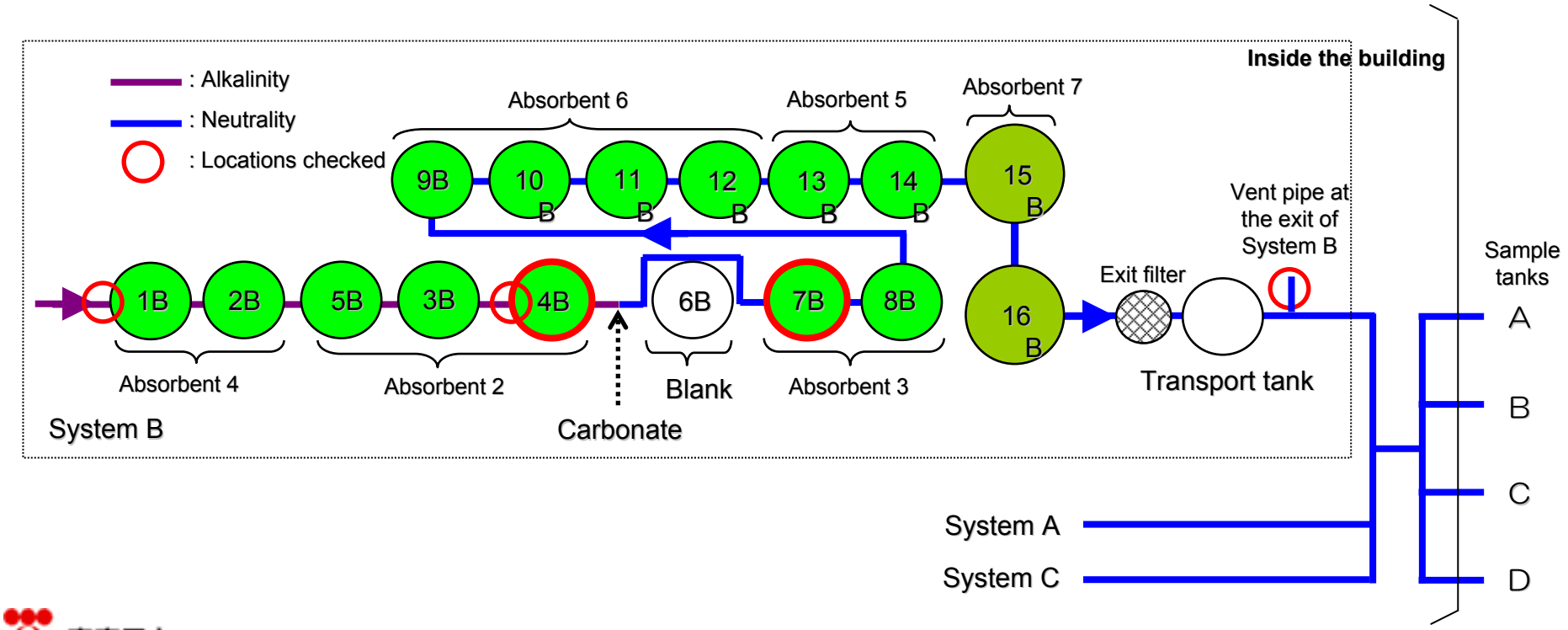
*1: Sr was removed at the Sr absorption tower and the pre-treatment facilities (carbonate coprecipitation)

*2: It was identified that carbonate had filtered though CFF 3B, which was then removed on Mar. 2 and replaced on Mar. 6 through 13. To note, no passing through of carbonate is identified with other CFFs than CFF 3B, and the same is true for CFF 3B after its replacement.

Policies on Probable Factor Evaluation and Root Cause Investigation (2/2)

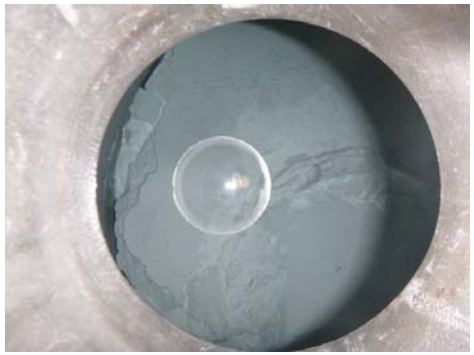
- Carbonate having passed though CFF 3B was caught at the absorption tower and was removed through reverse cleaning as it rose the differential pressure of the tower. But, such carbonate may have remained in pipes or in the tower to have reached at the exit.
- Especially, considering the fact that alkalinity in solution becomes neutralized after the Sr absorption tower (absorbent 2), it is estimated that carbonate was resolved and was quickly reached at the exit of the system.

➡ Conducted investigation on the inside of the absorption towers before (Absorption tower 4B) and after (Absorption tower 7B) neutralizing alkalinity in solution. The inside of the pipes was also investigated.



Root Cause Investigation Results (1/3)

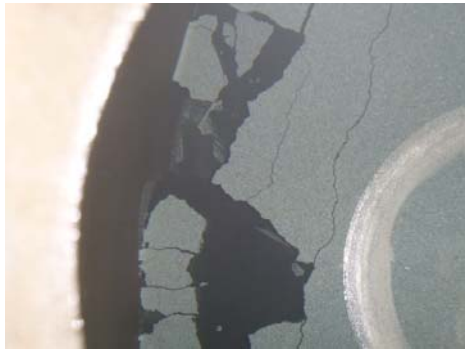
- Investigation results of the inside of the absorption towers



←Inside Absorption tower 4B (image taken from the inspection chamber at the upper part)

Gray colored sediment was confirmed on the surface of Absorbent 2 (estimated to be carbonate).

Inside Absorption tower B (Image taken from the inspection chamber at the upper part)→



A very small amount of gray colored sediment was confirmed on the surface of Absorbent 3

	Before injecting acid chemical agent*		After injecting acid chemical agent	
	pH	Ca concentration	pH	Ca concentration
Absorbent of Absorption tower 4B	12.2	0.1ppm or less	6.0	Approx. 145ppm
Absorbent of Absorption tower 7B	7.3	Approx. 0.2ppm	2.1	Approx. 1ppm

* Diluted with 200ml of purified water

Ca concentration was measured with samples taken from the surface layer of the absorbents (approx.10ml), to find that the concentration degree was high.

Thus, it is evaluated that carbonate had remained inside the both Absorption tower 4B and 7B.

Root Cause Investigation Results (2/3)

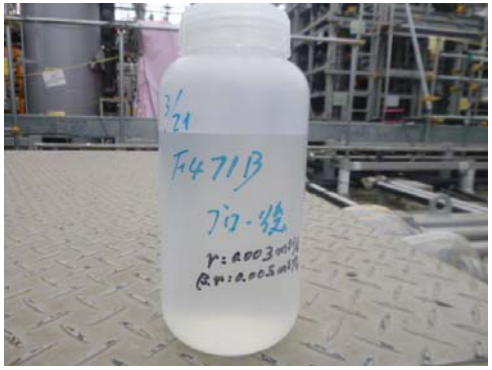
- Investigation results on the inside of the pipes

← Inside the pipe at the entrance of Absorption tower 1B

A foreign substance (in white color) slightly was found to be attached.

The opening of the pipe at the entrance of Absorption tower 4B →

No foreign substance (in white color) found to be existed.



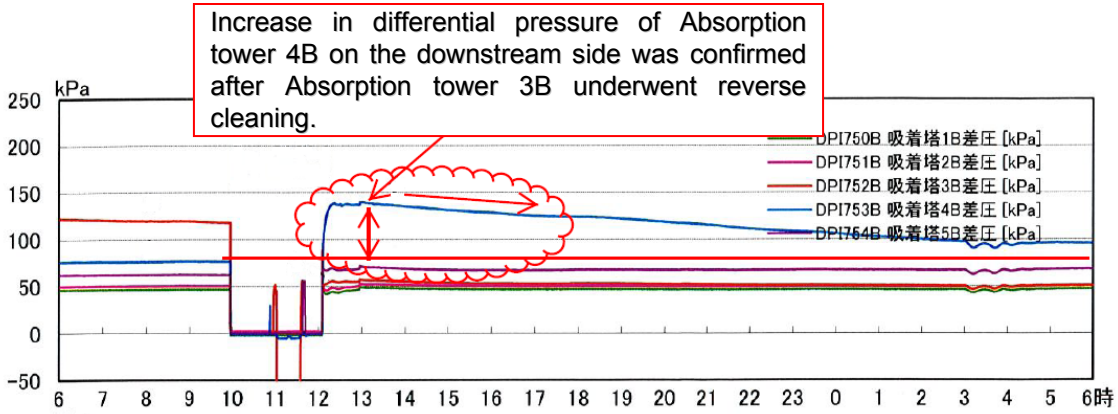
← No white sediment was found in the blow water taken from the vent pipe (the stagnation part) at the exit of System B.

Although a small amount of white foreign substance (estimated to be carbonate) was found to be attached to inside the pipe on the upper stream side of the absorption tower (Absorption tower 1B), since there were no substances identified after that, it is evaluated that carbonate has scarcely remained in the pipes.

Root Cause Investigation Results (3/3)

- Based on the fact that the existence of carbonate was found inside absorption towers, etc of System B, especially for a small amount of carbonate detected at the neutralizing zone of Absorption tower 7B, it is estimated that the carbonate remained had reached at the neutralizing zone to be dissolved, which resulted in increasing in radioactive density of gross β at the exit. Decontamination methods to deal with which are under study.

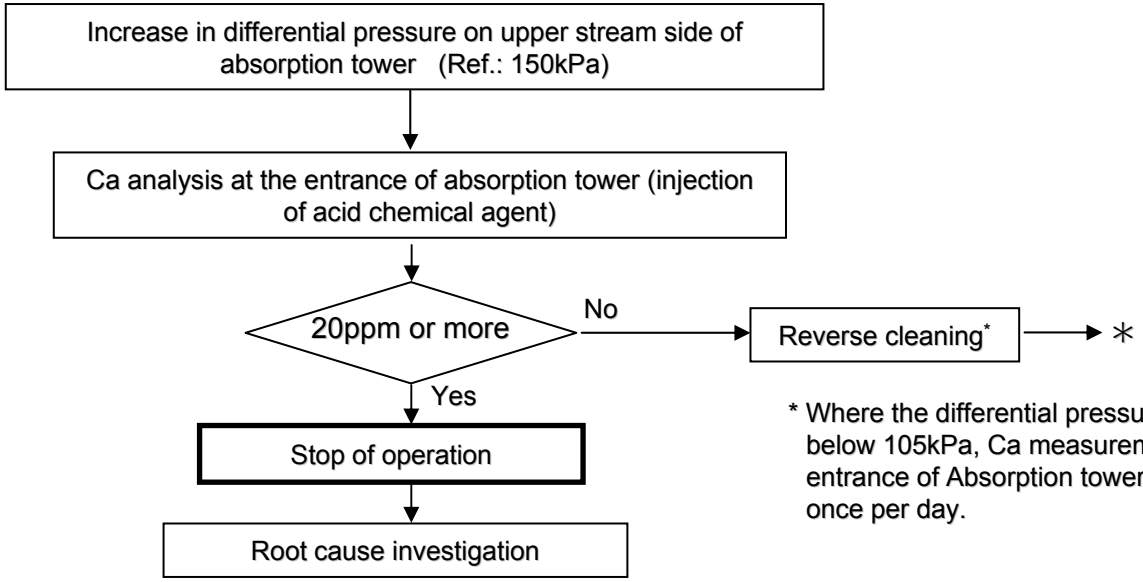
- It is estimated that the carbonate remained was slowly spread to the downstream side. Also, although the reverse cleaning seemingly worked effective to remove the most of the carbonate accumulated on the exterior of the absorption tower, but this may have equalized the carbonate remained to accelerate it passing through to the downstream side. (after the reverse cleaning, differential pressure increase on the downstream side was identified)



Example of differential pressure increase after reverse cleaning absorption tower
(Reverse cleaning at Absorption tower 3B, dated Mar. 14)

Recurrence Preventive Measures (Actions to prevent increasing radioactivity in outlet water)

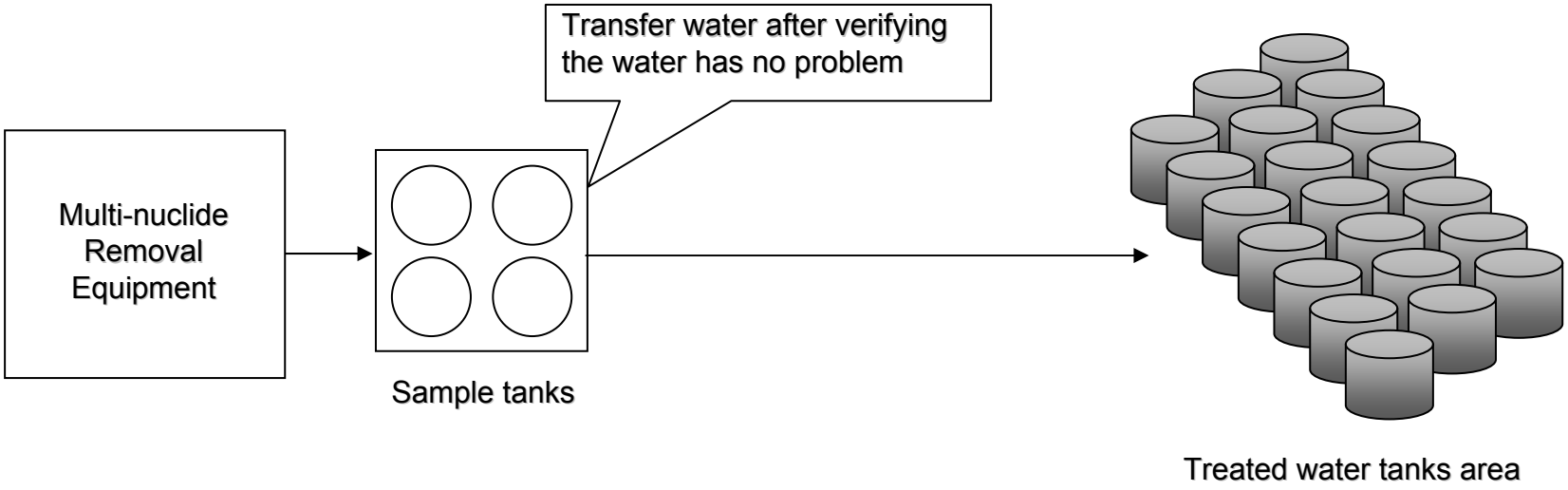
- Depending on the result of dismantle investigation of CFF 3B which allowed carbonate to pass through, recurrence preventive measures and horizontal deployment actions will be taken. (currently, decontamination methods are under study).
- Carbonate having passed through CFF increases the differential pressure on the upper stream side in the absorption tower (especially the first located one). It was in the middle of January or around when a tendency to increase the differential pressure of Absorption tower 1B was identified, which showed that it took almost two months (including about one month suspension period to undertake inspection) until the influence on the performance at the exit appeared, even taken into account some irregular works such as reverse cleaning were conducted.
- In future, if carbonate is observed to have passed through CFF, the action will be taken to stop the operation before it affects the performance ability at the exit following the judgment flow as shown below, which will also get acknowledged thoroughly among people concerned.



Judgment flow for implementation of reverse cleaning on the upper stream side of absorption tower

Recurrence Preventive Measures (Actions to prevent increasing in radioactive density in water at the exit)

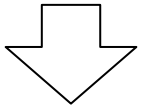
- In the event that the multi-nuclide removal equipment outlet water with high radioactivity flows into sampling tanks, to prevent its a into treated water tanks (J area, etc.), sample tank water is to be measured every time it is transferred to treated water tank to verify whether the radioactive density of the water is low enough to transfer.



Purification Operation through Systems (A) and (C) (1/2)

- Since Systems (A) and (B) have been identified of no abnormalities in their removal performances, and at this point, there is no osmosis of carbonate has been observed with CFF as well, it is available to use them as a source of water flow and water purification.
- For smoother operation of Systems (A) and (B), currently the application of two sample tanks (one for receipt and analysis and the other for transfer) is under study.

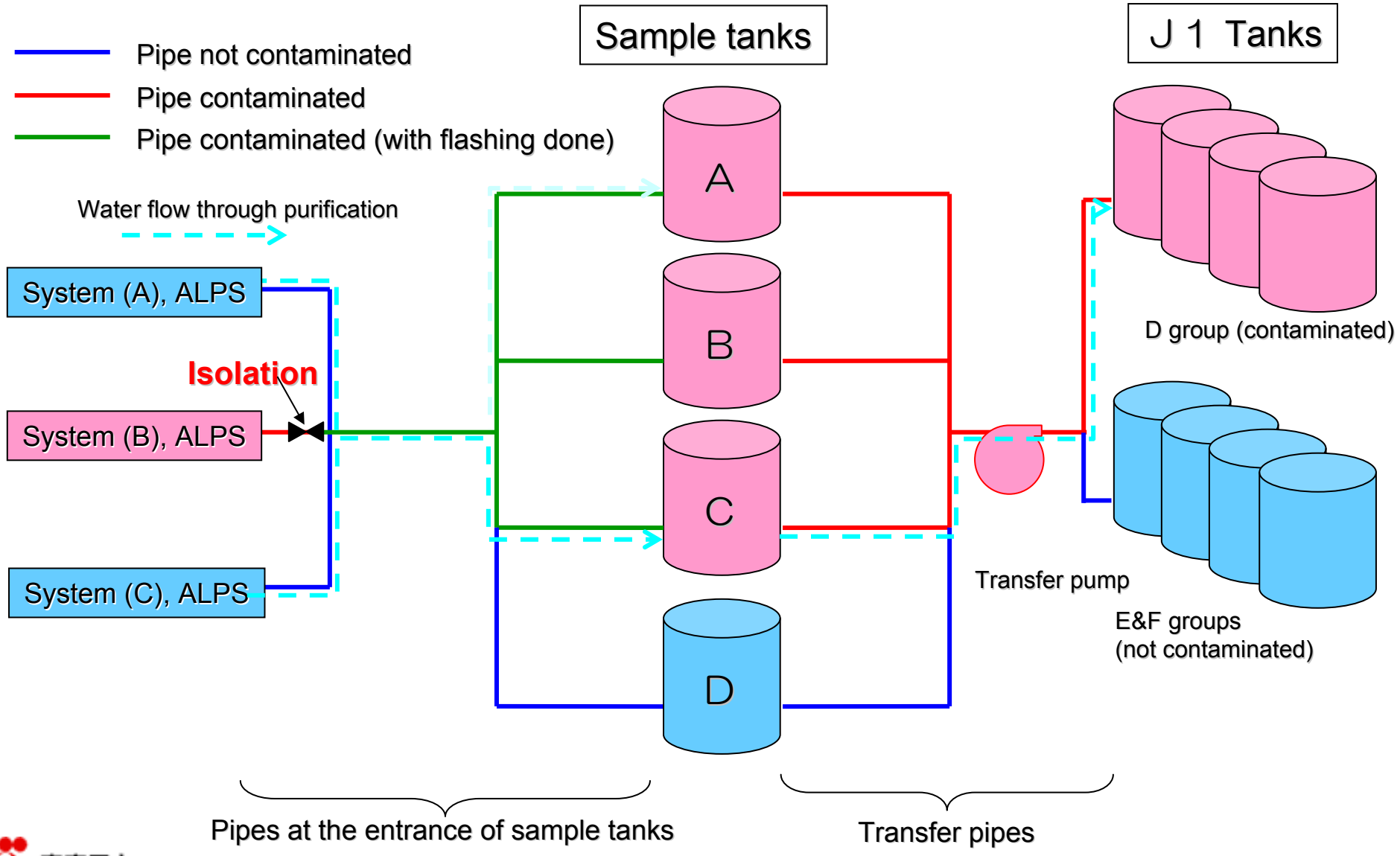
  → Firstly, utilize the sample tank C.
- The transfer pipe to J1 area has been found to be contaminated.



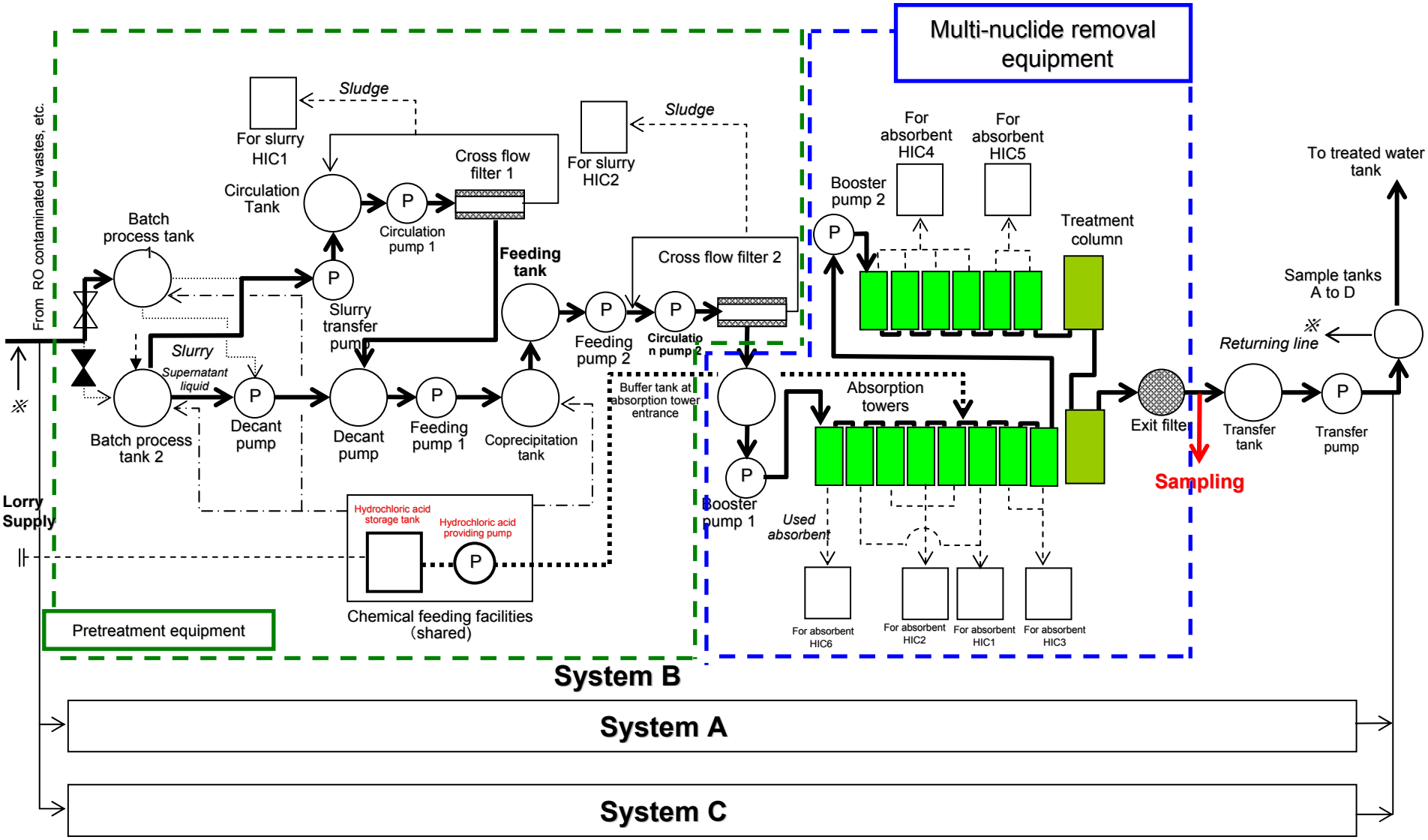
- From March 24, the operation with water flowing for the purpose of purifying the contaminated pipes and Sample tank C has been performed through Systems (A) and (C).
- The water having been used for the purification through water flowing will be transferred to Tank D at J1 (9 tanks) for a moment.
- To verify the result of the purification operation, the sampling and gross β value check will be conducted on the water in the pipes and sampling tanks.

Sampling location	Time	Target
Outlet water in System A	After start-up	Check if there is any abnormality existing.
Outlet water in System C	After start-up	Check if there is any abnormality existing.
Inlet water of Sample tank C	After start-up and before the tank becomes in full.	Check purification status.
Sample tank water	Before transferring (every time)	Check purification status.
Water in transfer line to Tank D in J1	At the time of transferring (every time)	Check purification status.

Purification Operation through Systems (A) and (C) (2/2)



【Reference】System layout



【Reference】Time-line

< Mar. 6 (Thu) to 13 (Thu) >

Having identified that slurry component was contained in outlet water on the osmosis side of CFF 3B through the root cause investigation conducted on the increase in differential pressure of the absorption tower on the upper stream side, the treatment operation of System (B) was suspended to carry out decontamination and inspection to the said CFF.

< Mar. 13 (Thu) >

14:32 Restarted the treatment operation of System (B)

< Mar. 14 (Fri) >

13:00 Conducted a periodic sampling of the outlet water in System (B), to find no abnormality in it.

< Mar. 17 (Mon) >

10:45 Conducted a periodic sampling of the outlet water in System (B).

< Mar. 18 (Tue) >

9:00 or around Studied the analysis results, to find high radioactive density in outlet water of System (B).

Gross β : 10^7Bq/L Order (at normal: 10^2Bq/L or around)

Other nuclides: 10^2～10^1Bq/L Order (equivalent to normal status)

12:04 Suspended the treatment operation of System (B) to clean CFF.

13:21 Identified high radioactive density in the water of Sample tanks A to C as a result of simplified measurement taken.

13:38 Suspended the treatment operation of System (A) (to stop the water transfer to the treated water tank ((D) in J1)

13:39 Suspended the treatment operation of System (c) (ditto)

No abnormalities (leakages, etc.) found to exist at the time of suspending the treatment operation of System (B)

【Reference】Investigation on the Extent of Influence

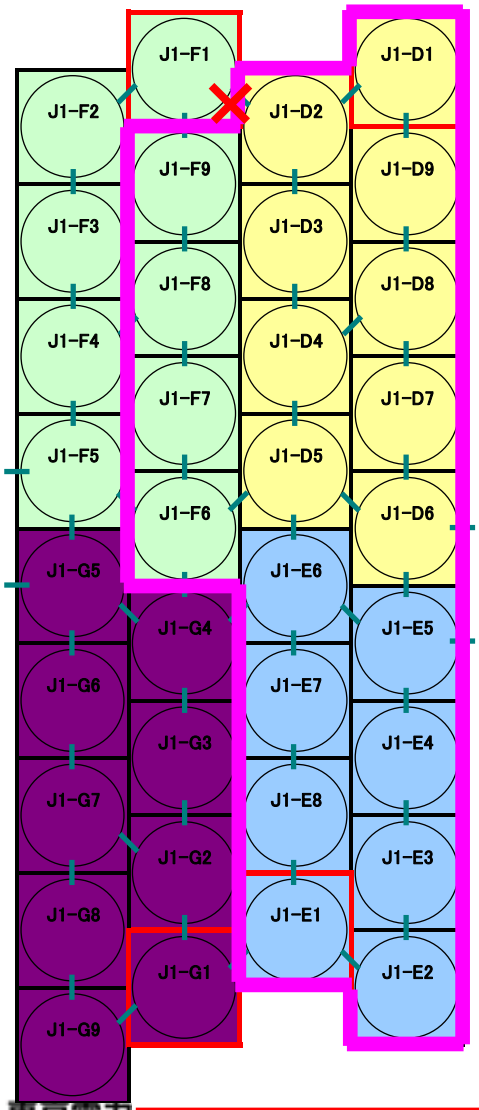
- The following sampling survey was conducted in response to the high radioactive density detected in the outlet water of System (B)

Location sampled	Sampling date	Analysis result (order)
Major points in System (B)	Mar.18 (Tue)	Detected high radioactive density after the Sr absorption tower (Gross β : 10^6～10^7Bq/L)
Sample tanks A to C	Mar.18(Tue)	Detected high radioactive density (Gross β : 10^6～10^7Bq/L)
Treated water tank (Receipt tank (D1) in D of J1 area)	Mar.18(Tue)	Detected high radioactive density (Gross β : 10^6～10^7Bq/L)
Treated water tanks (J1(D4,D5,D6 and D7))	Mar.19(Wed)	Detected high radioactive density in J1(D4,D5,D6 and D7) (Gross β : 10^4～10^5Bq/L)
Treated water tanks (J1(E5 and F7))	Mar.19(Wed)	Detected a normal level of radioactive density in J1(E5 and F7) (Gross β : 10^2Bq/L)
Outlet water in Systems (A) and (C)	Mar.17(Mon)	Detected a normal level of radioactive density (Gross β : 10^2Bq/L)

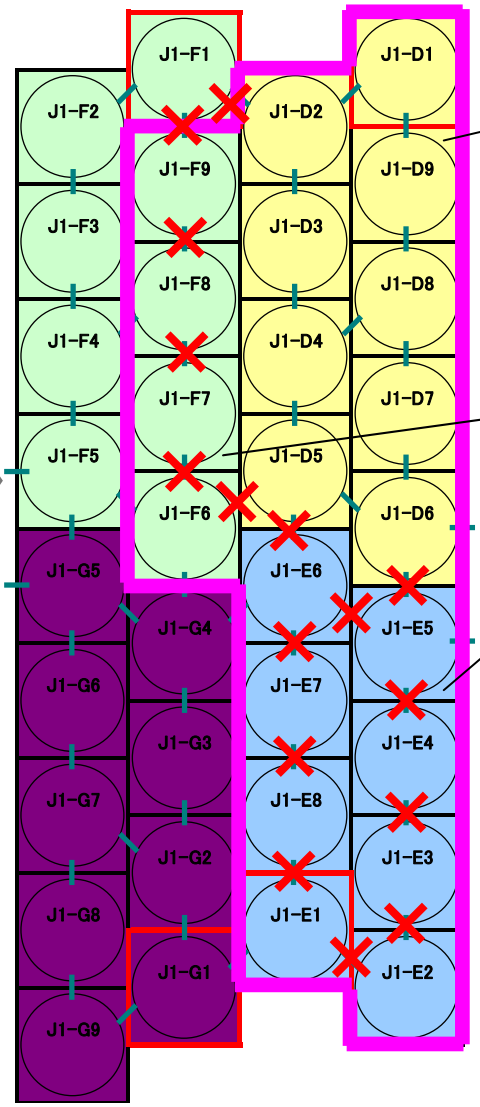
- High radioactive density was identified in the treated water tank (D1 to 9, Area D).
- **No abnormalities were detected with Systems (A) and (C)**

【Reference】Treated Water Receipt Tanks

Up to Mar. 18.
Opening/closing status
of communication valve



As of Mar. 24



: Treated water receipt tanks
(ones outside the line are yet to be constructed.)

: Valves being closed (as of Mar. 24)

【Area D】

Water quality: 10^4～10^7Bq/L

To be used as the place to which discharged water goes by cleaning operation.
Capacity of storage: approx. 1,500m^3

【Area F】

Water quality: 10^2Bq/L

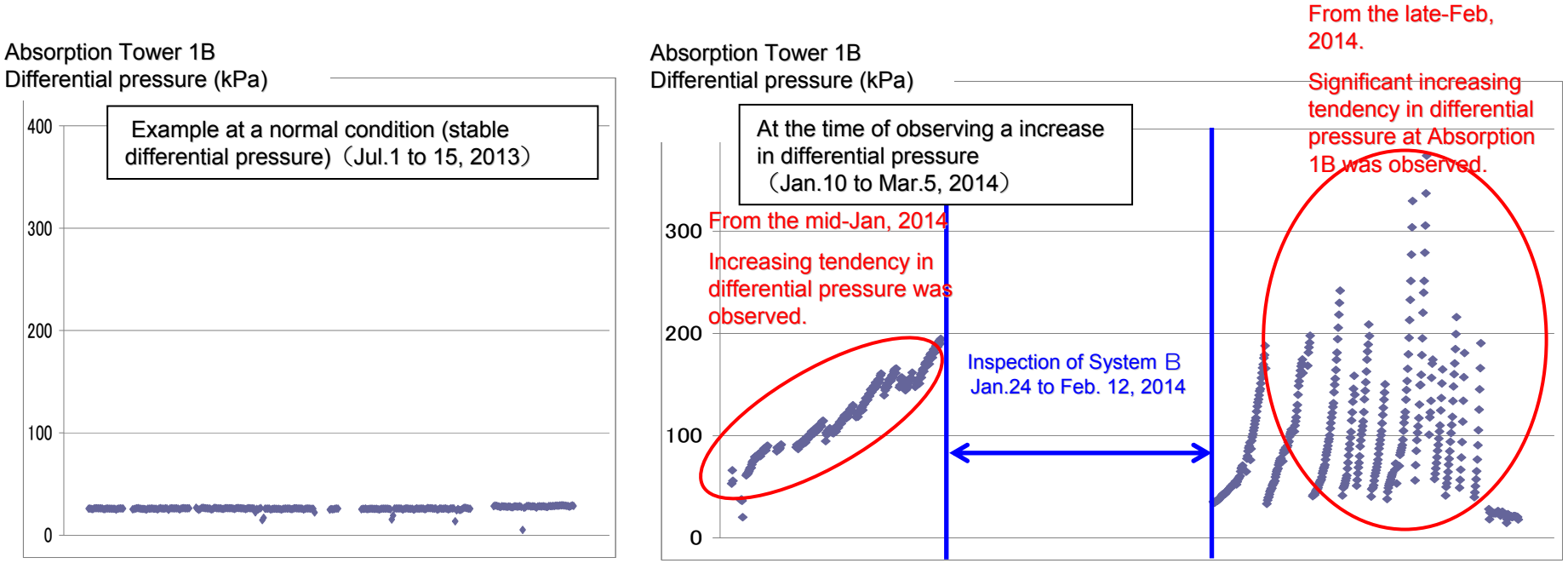
【Are E】

Water quality: 10^2Bq/L

Contamination detected in Area D
No contamination detected in Area E or D

【Reference】Estimation of Occurrence Timing of the Carbonate Osmosis with CFF 3B

- The carbonate slurry that had passed through CFF 3B was then caught at Absorption tower 1B, etc., resulted in increasing in differential pressure. A tendency to increase the differential pressure was already observed in the middle of January, based on which, the phenomenon, carbonate osmosis, is estimated to have occurred already around this time.



Over-time changes of differential pressure at Absorption tower 1B