

## Presumed cause of temporary increase in Strontium 90 concentration at the outlet of ALPS (A) at Fukushima Daiichi Nuclear Power Station and its recurrence prevention measures

<Reference Material>  
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TEPCO Holdings  
Fukushima Daiichi D&D  
Engineering Company

- Regarding the additionally installed ALPS (Multi-nuclide Removal Equipment) (A) brought online from July 27th to August 5th, it was confirmed that the concentration (93 becquerel/liter) of strontium 90 in the sample taken on July 28th of the outlet water (refer to figure in page 4) was higher than the regulatory concentration limit (30 becquerel/liter). It was also confirmed that the concentration (2.7 becquerel/liter) of the water sampled at the same location on August 4th was below the regulatory concentration limit.
  - ✓ The water sampled on July 28th indicated that major radionuclides\* excluding Strontium 90 were below the regulatory concentration limit
  - ✓ The water sampled on August 4th indicated that the sum of the ratios to regulatory concentration limits for the seven major radionuclides including Strontium 90 was less than [1]
    - ※cesium 134, cesium 137, cobalt 60, antimony 125, ruthenium 106, iodine 129
- All treated water is stored in the tanks, and has not been discharged into the environment. Also, sampling was conducted when storing water treated from July 31st to August 5th in the temporary storage tank (refer to figure in page 4), and it was confirmed that the strontium 90 concentration (4.2 becquerel/liter) fell below the regulatory concentration limit. Based on these results, it is presumed that this case only represents a temporary increase in strontium 90 concentration.
- To investigate the cause, further sampling was conducted on September 5<sup>th</sup> with additional confirmation points. Analysis of sampled water confirmed that the seven major radionuclides including Strontium 90 were below the regulatory concentration limits, and also confirmed that the sum of the ratios to regulatory concentration limits were less than [1], which means that there are no abnormalities in sampled water and no issues in the performance of additionally installed ALPS (A) to remove radioactive material. We shall continue to investigate the cause.

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- As a result of confirming details of periodic inspection conducted prior to operation on July 27<sup>th</sup> as well as operation data from around July 28<sup>th</sup>, the cause of temporary increase in Strontium 90 concentration was presumed to be the impact of change in pH (hydrogen ion concentration) environment in the absorption tower after the conduct of draining, filling of all absorption towers (total of 18 units) during the periodic inspection.
- Based on this presumed cause, the scope of draining and filling for absorption towers during periodic inspection shall be appropriately reviewed in the future, and sampling shall be conducted at the outlet after concluding the periodic inspection to check for impact from draining and filling to prevent recurrence.

# 1. Results of confirming details of periodic inspection conducted prior to operation on July 27

- As temporary increase in Strontium 90 concentration was confirmed from water sampled on July 28<sup>th</sup>, details of periodic inspection (conducted from March 2022 to July) conducted for the additionally installed ALPS (A) prior to operation on July 27<sup>th</sup> were checked.
- As a result, it was confirmed that all absorption towers (total of 18 units) were subjected to draining and filling (feeding of filtered water)\* as part of initiatives for preventative maintenance starting this inspection (first time where all absorption towers were subjected to draining and filling during inspection).
- All absorption towers being subjected to filling (feeding of purified water) may have caused the pH (hydrogen ion concentration) in the absorption towers to deviate from normal values.
- It has been confirmed that other than the water draining and filling conducted for all absorption towers, there are no other differences between this inspection and other inspections performed previously. It has also been confirmed that all inspections, including the water draining and filling process, were conducted in accordance with the steps stipulated in procedures.

\*Draining is necessary to inspect and replace components (such as valves and pipes). Also, water filling is necessary for startup after concluding inspection.

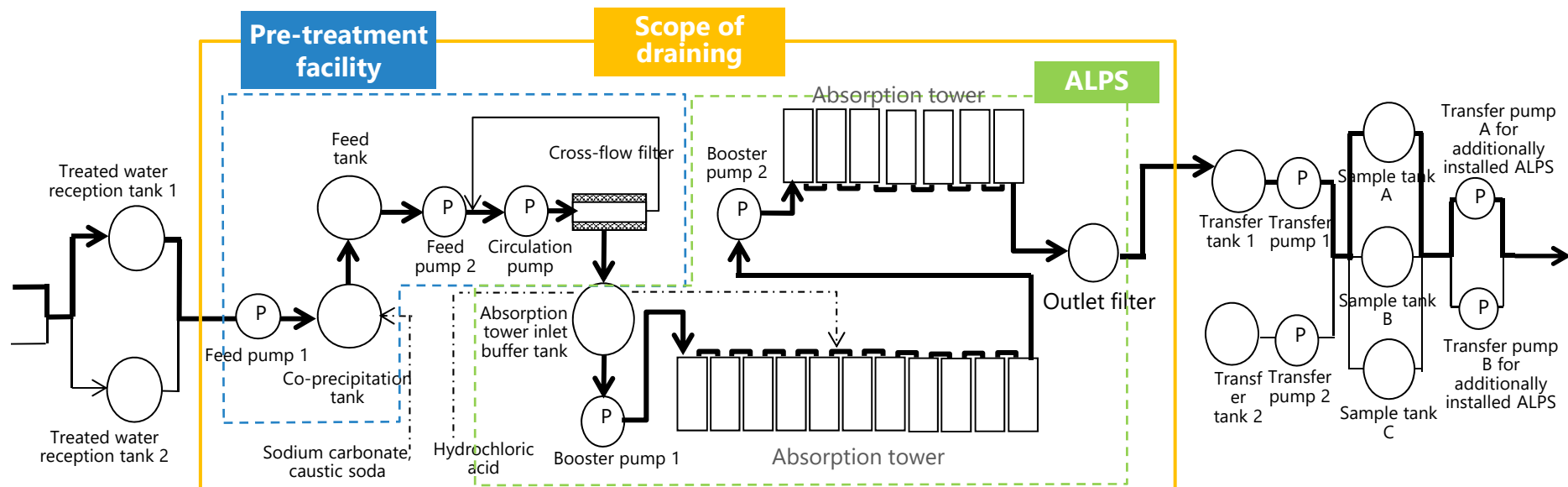


Figure. Scope of draining during periodic inspection of additionally installed ALPS (A)

## 2. Results of confirming operation data from around July 28th

- Due to the temporary increase in Strontium 90 concentration being confirmed from water sampled on July 28<sup>th</sup>, operation data of the additionally installed ALPS (A) around July 28<sup>th</sup> was also confirmed.
- As a result, it was confirmed that from July 27<sup>th</sup> to 28<sup>th</sup>, the pressure differential at the outlet filter (which is the difference in pressure between the filter inlet and outlet) had experienced an increase and a decrease, which was unprecedented based on past operations.
- Based on this data, it is possible that some material was temporarily clogging the outlet filter.
- A visual inspection was conducted for the outlet filter, and it was confirmed that there were no abnormalities such as physical damage, etc. Also, the operation data for additionally installed ALPS (A) was confirmed, and it was verified that there were no data that significantly deviated from normal status other than the outlet filter pressure differential.

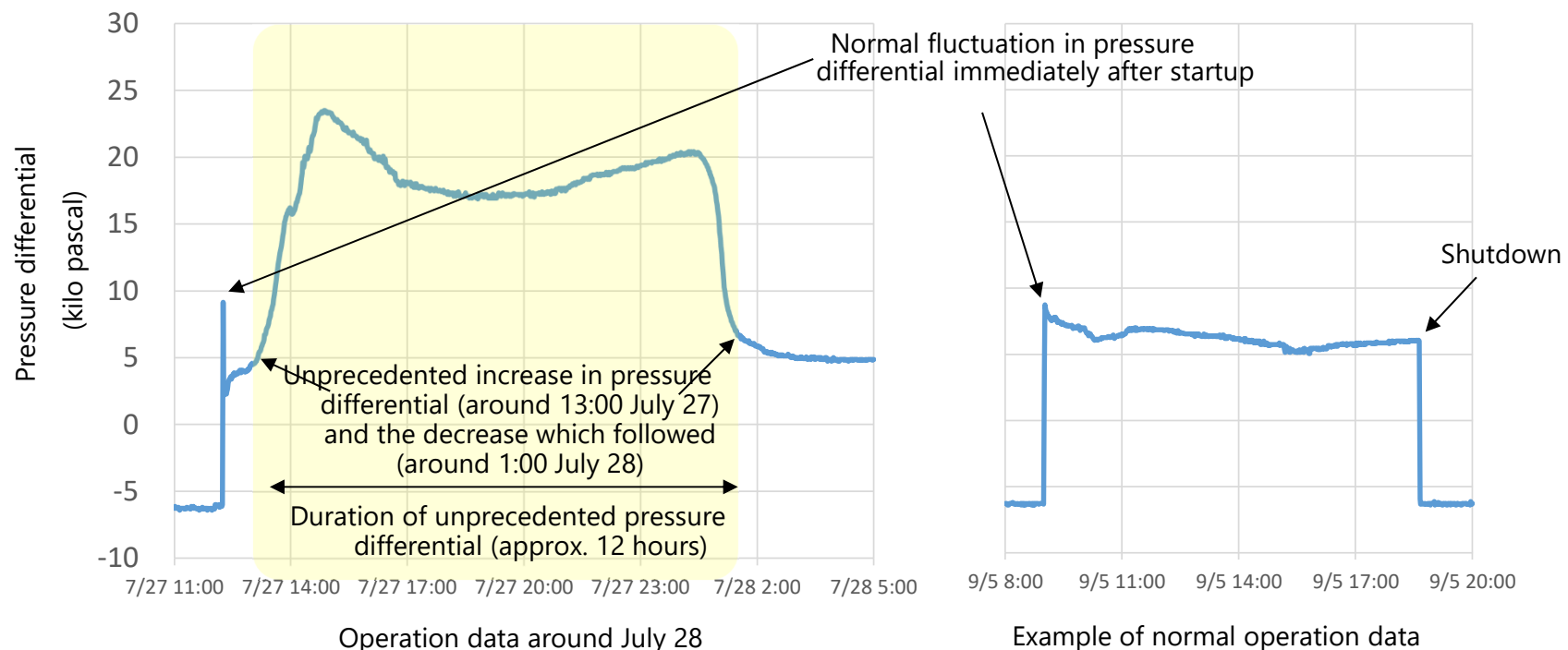


Figure. Trend graph of pressure differential of outlet filter for the additionally installed ALPS (A)

### 3. Presumed cause of temporary increase in Strontium 90 concentration

- Impact of water draining and filling conducted for all absorption towers

- ✓ ALPS has a set pH (hydrogen ion concentration) to ensure optimal treatment by each absorption tower. The system is designed to check pH at two points, where is within the pre-treatment facility and is between absorption towers 5 and 6. This allows the proper absorption of radioactive material in each absorption tower (Strontium adsorbent set pH to (12)) .
- ✓ On the other hand, it was presumed that the Strontium adsorbent had fluctuated slightly to the neutral side from the normal pH (12 (alkaline)) immediately after commencing operation (on July 27) due to all absorption towers being subjected to water draining and filling (feeding of filtered water) during this periodic inspection.
- ✓ The pH of the Strontium adsorbent fluctuating to the neutral side makes it easier for precipitates\* captured by the Strontium adsorbent to dissolve when compared to pH [12]. This could have caused precipitates containing Strontium 90 to micronize and separate, allowing it to continue into the absorption towers of later stages.

\*Precipitates contain much calcium and magnesium, but also traces of Strontium 90.

- Presumed cause of the unprecedented increase and decrease of outlet filter pressure differential

- ✓ It is presumed that minute precipitates containing Strontium 90 flowing out of the Strontium adsorbent were captured by the outlet filter (2µm mesh) after passing through each adsorbent towers, resulting in the filter becoming clogged and increasing the pressure differential.
- ✓ Minute precipitates containing Strontium 90 captured at the outlet filter dissolved and micronized while being held for several hours in a pH [7(neutral)] environment and being subjected to the water flow of the ALPS system, and passed through the outlet filter. This caused the outlet filter pressure differential to drop and **resulted in the Strontium 90 concentration in water passing through the outlet filter to increase.**

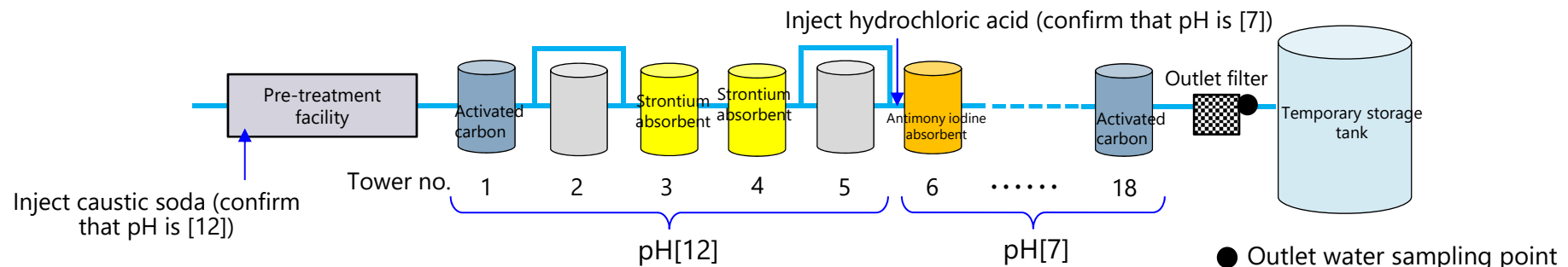


Figure. pH for each absorption tower in the additionally installed ALPS (A)

## 4. Review of recurrence prevention measures with considering the presumed cause

- Considering the presumed cause for the temporary increase in Strontium 90 concentration, the recurrence prevention measures below to be taken during periodic inspection shall be reviewed.

### [Measure 1] Review the appropriate scope for water draining and filling during periodic inspection

- ✓ In the most recent periodic inspection of ALPS, all absorption towers were planned to be subjected to water draining and filling as initiatives for preventative maintenance.
- ✓ Future inspection methods shall be reviewed based on the experience gained to prevent occurring of significant changes in the pH environment within the absorption tower, such as not conducting water draining and filling for absorption towers (total of five towers) with pH set to [12] at once.
- ✓ To confirm that absorption towers with pH set to [12] are at appropriate levels when conducting water draining and filling, sampling shall be conducted at later stages of absorption towers that have been inspected to verify effectiveness of measures.

### [Measure 2] Strengthen monitoring of outlet filter pressure differential after concluding periodic inspection and sampling of outlet water

- ✓ Swiftly detect possibilities of the decrease in capabilities to treat and purify radioactive materials, caused by fluctuation in the status of absorption towers including changes in the pH environment.
  - ✓ Consider experiences gained to strengthen monitoring of outlet filter pressure differential after concluding periodic inspection. Also, conduct sampling of outlet water after startup to confirm that water is being treated appropriately to remove radionuclides.
- Regarding additionally installed ALPS (B), of which all its absorption towers were subjected to water draining and filling in the same way as the additionally installed ALPS (A), the (B) system underwent treatment operation in September 9<sup>th</sup>. It was confirmed that the concentration of Strontium 90 in the temporary storage tank storing treated water was below the regulatory concentration limit (6.1Bq/liter). It is presumed that additionally installed ALPS (B) contained less captured precipitates because the absorbent in the Strontium absorption tower that adsorbed the most Strontium 90 located upstream had been replaced. In the future, we will continue to appropriately implement the measures reviewed this time.
  - We will continue to confirm the effectiveness of these recurrence prevention measures, and take appropriate measures to conduct purification and treatment using ALPS.