Evaluation of the report of Tokyo Electric Power Company regarding the leakage from the RO-treated water storage tank at the Fukushima Daiichi Nuclear Power Station

15 April 2015
Nuclear Regulation Authority, Japan

1. Overview

Around 20:00 on 2 October 2013, a worker found that RO-treated water[2] stored in the B-A5[1] tank in the B south tank area was leaking from the tank ceiling plate, and that some of this water had leaked outside the dike[3] (refer to Figure 1). On that day, there was a risk that rain water containing radioactive materials (hereinafter referred to as "accumulating water inside the dike") would leak outside the dike due to the approaching typhoon. Therefore, water was being pumped up to the B-A5 tank, which is one of the five tanks connected by connection pipes (tanks B-A1 to B-A5), but leakage occurred from the B-A5 tank, which had become filled with water (refer to Figure 2).

Though the water level of the tank was being monitored by the water level gauge attached to the B-A1 tank, the water level of the B-A1 tank, which was located at the highest position among the five tanks, was displayed as being the lowest.

In the same day, the Nuclear Regulation Authority (hereinafter, referred to as "NRA") received the report regarding accidents and failures based on the Article 62-3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors from Tokyo Electric Power Company (hereinafter, referred to as "TEPCO").

Subsequently, the NRA received the report regarding causes and countermeasures of the aforementioned event (the final report) from TEPCO as of 6 December 2013 (partially corrected on 31 October 2014) and the NRA reviewed the contents and summarized the evaluation result.

Report from TEPCO
http://www.nsr.go.jp/activity/bousai/trouble/20141031-2.html

1 The name given to each tank
2 Desalinated water that has been treated by reverse osmosis treatment system and is used for purposes such as nuclear reactor water injection
3 A concrete foundation and dike designed to prevent the water from leaking out into the site even if water leaks outside the tank

2. Overview of the report submitted by TEPCO

(1) Environmental impact assessment (expansion of contaminated water)

The amount of leakage from the B-A5 tank was approximately 20 m^3 based on an evaluation of the records of tank water level changes. From this amount, it is estimated approximately 0.43 m^3 leaked outside the dike based on an evaluation of the status of leakage from a drain hole on the tank catwalk.

On the morning of the day following the day leakage occurred, seawater near the south discharging outlet (near the C drainage ditch outlet) (T-2) was monitored. The results indicated Cs-134, Cs-137 and total beta were all less than the detection limits (detection limit: 1.5 Bq/L for Cs-134, 1.2 Bq/L for Cs-137, and 20 Bq/L for total beta) (Figure 3), showing no obvious increase when comparing the values before and after leakage occurred (Figure 4).

(2) Investigation of the situation regarding tank installation and management

The five tanks in the B south tank area (tanks B-A1 to B-A5) are arranged in series from west to east (starting with the B-A1 tank) and are connected by connection pipes. Due to the gentle decline from the site's west side to its east side, the B-A1 tank is positioned highest and has the lowest water level display. Although the tank water levels were monitored by the water level gauge attached to the B-A1 tank, neither the maximum tank water level nor a tank water level confirmation method considering inclination had been clarified.

(3) Investigation of the situation at the time of confirmation of leakage from the B-A5 tank

Before leakage was confirmed around 20:00 on 2 October 2013, there was a report of suspected leakage. However, leakage checking, reporting, communication and consultation were not performed appropriately at the site and thus discovery of the leakage was delayed.

(4) Countermeasures

(4)-1 Countermeasures related to tank operation

The main operation-related causes of leakage include the following: neither tank operational management procedures considering inclination nor a method for setting the maximum water level had been established; water levels were checked from the manholes in the centers of the tanks, but no report was submitted to the general manager in charge of the tanks when it was judged there had been no leakage; and risk

prediction was not adequately performed due to insufficient information sharing within the department in charge of tank management. Taking these causes into consideration, the following countermeasures were implemented.

- Operational procedures, including a method for setting the maximum water level according to the tanks' installation situation, have been clarified.
- In principle, the water inside the dike is not pumped into tanks inside the same dike. However, when doing so is unavoidable, the actual water level is checked from the manholes at the tops of the tanks and remotely monitored by the operation management team in the water treatment facility control room in order to detect leakage at an early stage.
- If problems such as leakage are found, reporting, communication, and consultation are thoroughly performed and information is shared among concerned parties.

(4)-2 Countermeasures related to equipment

The main equipment-related causes of leakage include the following: the transfer destination of accumulating water inside the dike was not secured, not all tanks were equipped with water level gauges, and the tanks had insufficient sealing properties.

Taking these causes into consideration, the following countermeasures were implemented.

- In order to secure the transfer destination for accumulating water inside the dike, a new temporary tank group (notch tanks with a total capacity of 4,000 m^3) was installed.
- Water level gauges were installed in all flange-type and welded tanks.
- The tank ceiling plates were caulked to improve their sealing properties, and the dike heights were increased to prevent accumulating water inside the dike from leaking outside the dike.

3. NRA's evaluation with regard to the report submitted by TEPCO and the future response

(1) Environmental impact

There is no obvious fluctuation in the results of monitoring before and after the leakage occurred into seawater near the south discharging outlet (T-2) of the C drainage ditch. Based on the facts above, the NRA evaluates that there has been no contamination of the ocean that raises any concern about influence to health and the environment.

(2) Exposure radiation dose

The effective dose caused by gamma rays and equivalent dose to skin caused by beta rays were evaluated for the workers who patrolled the B south tank area (refer to Table 1). Neither the effective dose nor the equivalent radiation dose showed significant differences before and after discovery of the leakage. The NRA therefore concludes that there has been no exposure leading to concern for the workers who conducted the patrol.

(3) Countermeasures

TEPCO has implemented countermeasures related to the tank operation and equipment based on the causes of this event (refer to Table 2). The NRA has evaluated them as follows, and countermeasures summarized by TEPCO shall be checked about its implementation situation at an appropriate timing by safety inspection, etc.

(i) Countermeasures related to operation

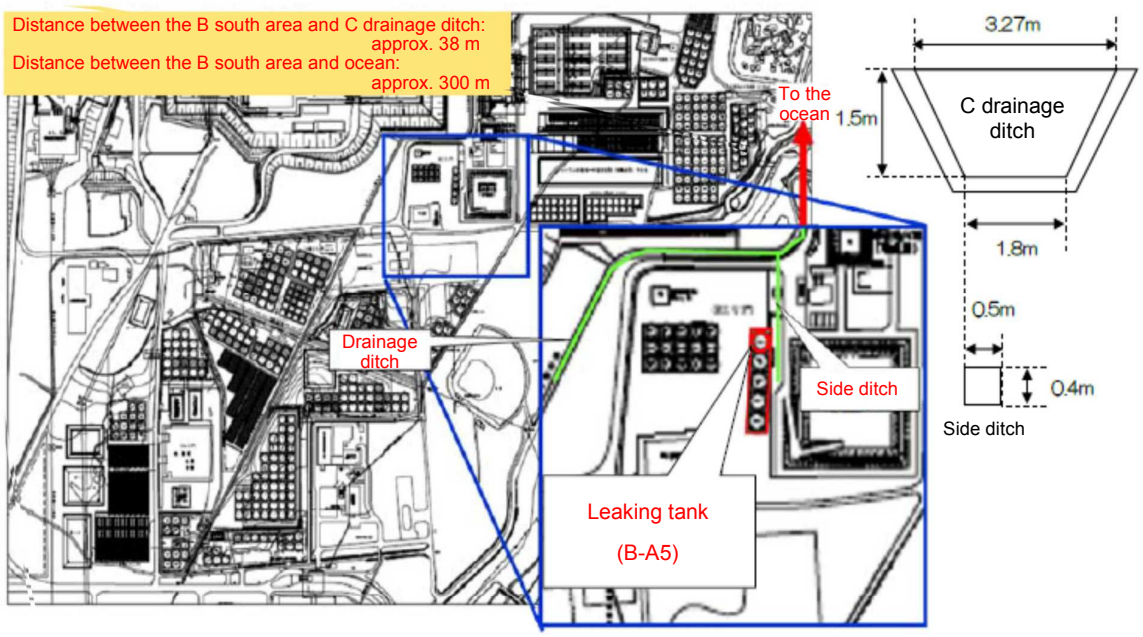
As of February 2014, implementation of countermeasures related to tank operation had been completed. With respect to the pumping up and transfer of accumulating water inside the dike, operation guidelines have been created; these define the principle of not pumping water into tanks inside the same dike and stipulate a water level management method and procedure in cases in which doing so is unavoidable. The NRA confirmed through a meeting with TEPCO that TEPCO has enhanced human resources and management at the site in addition to promoting information sharing and ensuring thorough reporting, communication and consultation within the department in charge of tank management.

The NRA thus concludes that these countermeasures have been prepared based on the main causes of the leakage related to tank operation and will be effective if implemented appropriately.

(ii) Countermeasures related to equipment

As of July 2014, implementation of countermeasures related to equipment (installing the tanks with water level gauges, securing a transport destination for accumulating water inside the dike, increasing the dike height, etc.) had been completed and operation began.

The NRA thus concludes that these countermeasures have been prepared based on the main equipment-related causes of the leakage and will be effective in reducing the risk of leakage occurrence and spread if implemented appropriately.



B-A5 tank leakage points

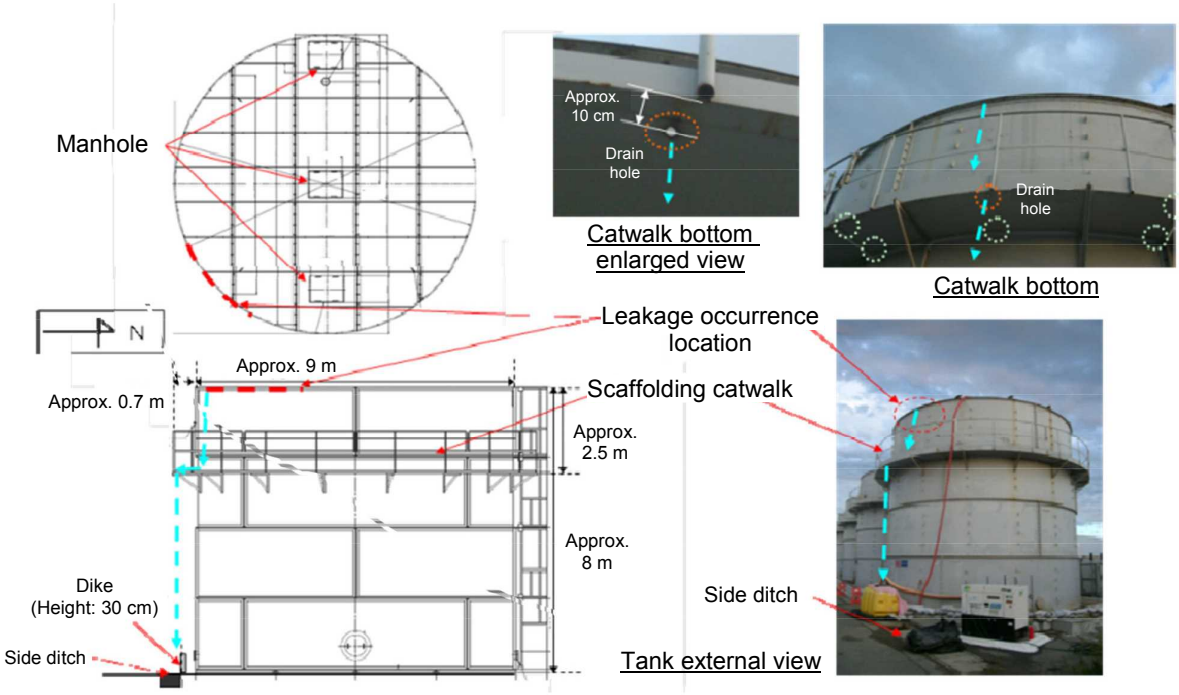
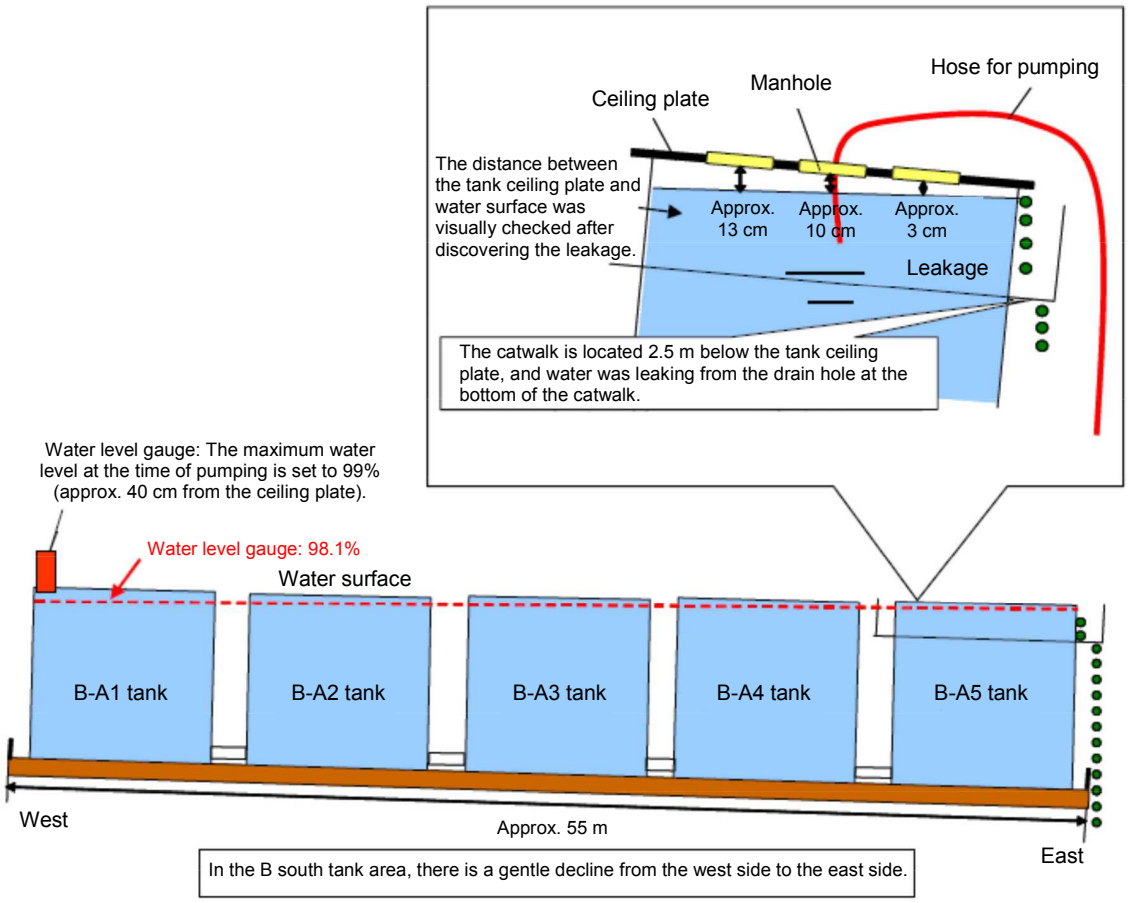


Figure 1 B south tank area and B-A5 tank leakage points (extracted from the TEPCO report)

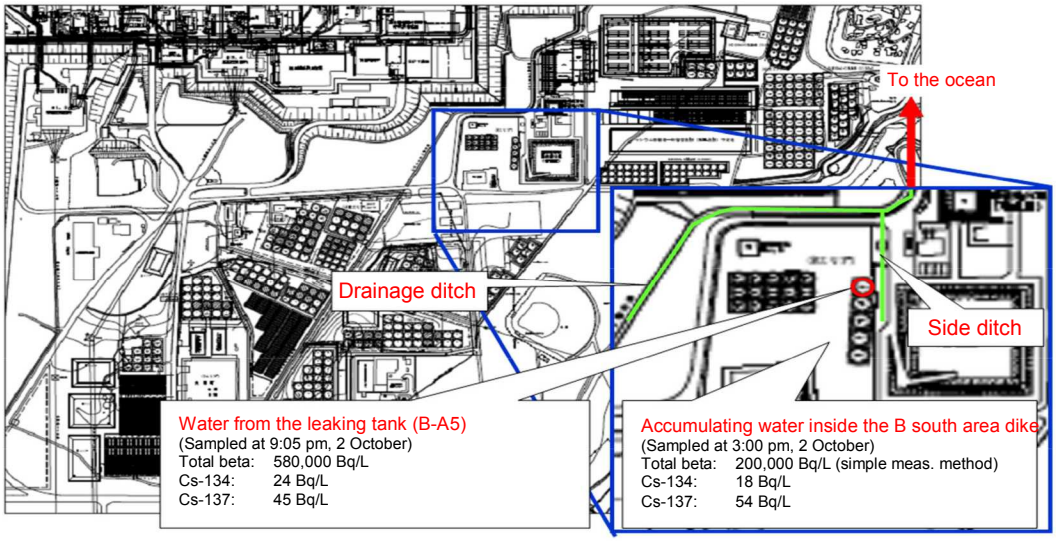
Tank installation situation in the B south tank area



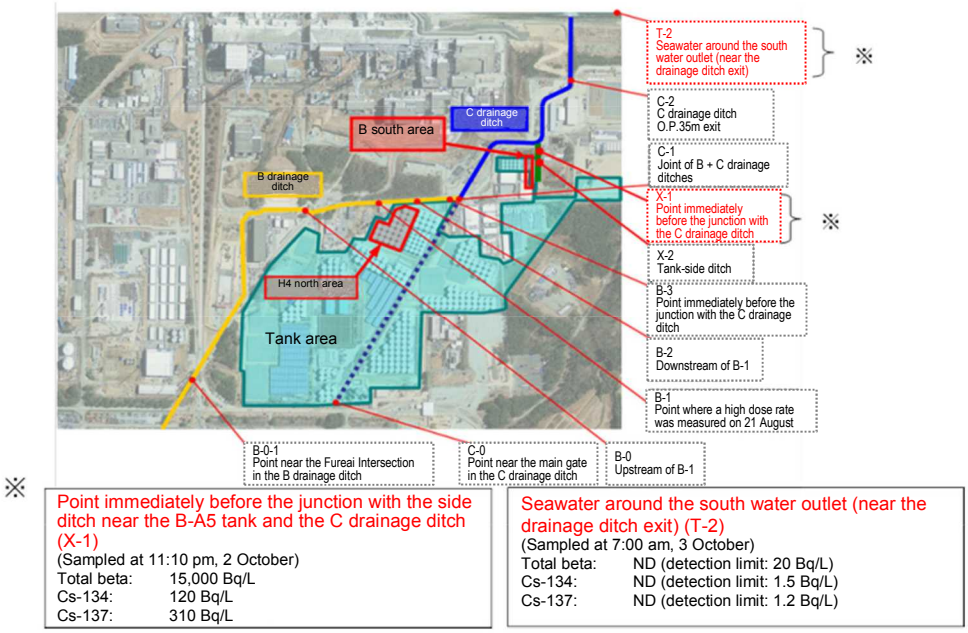
- Tank water levels were monitored using the water level gauge of the tank at the west end (B-A1).
- The maximum water level for the water level gauge was set to 99% for the tank at the west end (B-A1) (approx. 40 cm from the ceiling plate) (water had been pumped up to the maximum water level because urgent pumping was necessary due to an approaching typhoon).
- Due to the inclination of the B south tank area site, the water level at the edge of the tank at the east end (B-A5) reached the tank ceiling plate when the water level exceeded 98.1% according to the water level gauge of the tank at the west end (B-A1).
- Although most of the water that leaked from the tank at the east end (B-A5) leaked within the B south tank area dike from the gaps in the tank side plates and catwalk, some of the water leaked outside the B south tank area dike from the drain hole at the bottom of the catwalk (scaffolding used for inspection) installed around the tank.

Figure 2 Tank installation situation in the B south tank area (extracted from the TEPCO report)

Results of analysis regarding leakage from the B-A5 tank



Results of analysis of water around the B-A5 tank



翻訳版に修正

Figure 3 Results of analysis regarding leakage from the B-A5 tank (extracted from the TEPCO report)

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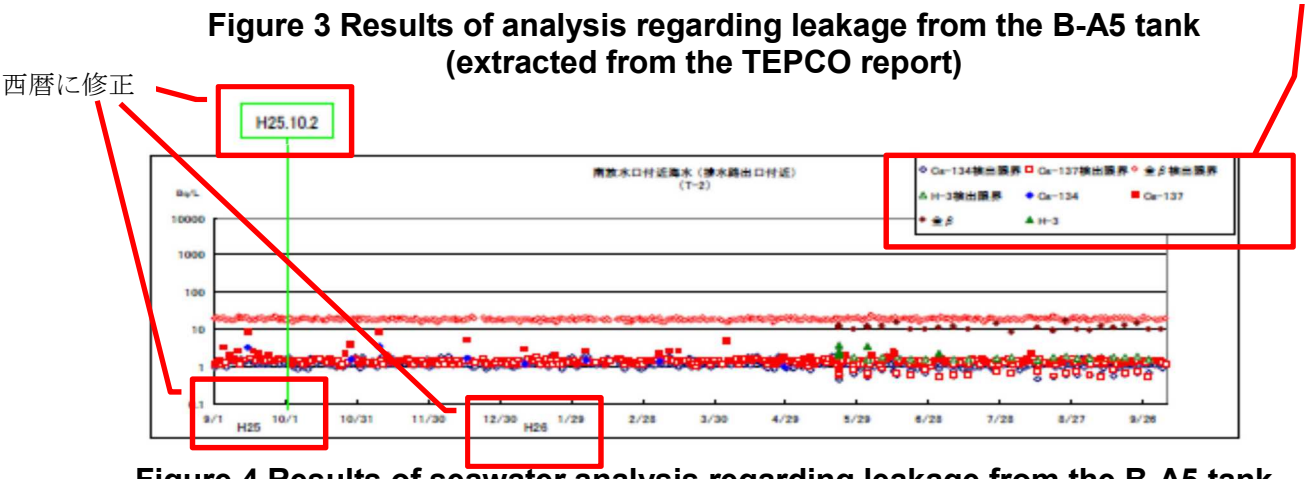

Figure 4 Results of seawater analysis regarding leakage from the B-A5 tank (extracted from the Secretariat of the NRA's document for a meeting with

TEPCO)

Table 1 Radiation exposure dose evaluation results (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

Differences in workers' exposure doses	Effective dose (gamma rays)		Equivalent radiation dose (skin, beta rays)	
	Annual dose limit: 50 mSv		Annual dose limit: 500 mSv	
	Avg. dose per a single entry [mSv]	Max. dose per a single entry [mSv]	Avg. dose per a single entry [mSv]	Max. dose per a single entry [mSv]
Tank patrol				
Before finding leakage (25 Sept–1 Oct.)	0.03	0.12	0	0
On the day the leakage was found (2 Oct.)	0.03	0.08	0	0
After finding leakage (3‐9 Oct.)	0.03	0.10	0	0

Table 2 Countermeasures related to leakage from the tank ceiling plate in the B south area (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

Category	Countermeasure	Date completed
Operation-related countermeasures	Creation of operation guidelines for collection and transfer of accumulating water inside the dike	3 December 2013
	Enhancement of site management	Mid October 2013
	Enhancement of human resources	Early February 2014
	Sharing of equipment information	Early December 2013
Equipment-related countermeasures	Securing a transfer destination for accumulating water inside the tank area dike (transfer to the 4000t notch tank group)	Mid October 2013
	Securing a transfer destination for accumulating water inside the tank area dike (installation of a tank for storage and treatment of rainwater inside the dike)	Mid January 2014
	Tank ceiling plate caulking	Early February 2014
	Drain hole sealing (temporary measure: sealed using sealing tape)	2 October 2013
	Drain hole sealing (permanent measure: closing holes by repairing materials, ensuring protection using waterproof tape)	Late January 2014
	Installation of water level gauges for each tank (flange-type tanks)	Late November 2013
	Installation of water level gauges for each tank (welded tanks)	Mid March 2014
	Transferring water until the water level of each tank in the B south tank area is below 100%	22 January 2014
	Increasing the dike height of the tank area dike (increasing dike height with a steel plate)	Late December 2013

	Increasing the dike height of the tank area (achieving adequate dike height)	Early July 2014
	Installation of rainwater gutters atop the tanks (prevention of rainwater inflow)	Late July 2014