

Evaluation of the report of the Tokyo Electric Power Company regarding the leakage from the double strainer differential manometer for the water transfer pipes of the desalination system at Fukushima Daiichi Nuclear Power Station

15 April 2015
Nuclear Regulation Authority, Japan

1. Overview

Around 11:05 on 6 February 2014, the double strainer differential manometer of the water transfer pipe connected to the reactor water-injection equipment (hereinafter, referred to as the “differential manometer”) was found to be leaking RO-treated water.¹

RO-treated water that had leaked from the differential manometer spilled out of the drain water receiver of the mount installed in the lower part of the double strainer and permeated the soil. Tokyo Electric Power Company (hereinafter, referred to as “TEPCO”) confirmed that there was no indication that the leaked water had flowed outside the wall of sandbags placed around the mount, and there was no trace of water flow in the side ditch near the location of the leakage.

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 TEPCO.

Subsequently, the NRA received the report regarding causes and countermeasures of the aforementioned event (the final report) from TEPCO as of 30 June 2014 (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/20141031-4.html>

¹ Desalinated water that has been treated by reverse osmosis wastewater treatment equipment and is used for nuclear reactor water injection (refer to Figures 1 and 2).

2. Overview of the report submitted by TEPCO

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

The amount of RO-treated water that leaked from the differential manometer was approximately 600 L based on the changes in flowmeter readings. According to the

analysis results, the radioactivity concentration was estimated to be approximately 9.3×10^4 Bq/L for total beta and approximately 3.8×10^5 Bq/L for tritium. Based on these results, the amount of radioactivity of the leaked water was calculated to be approximately 5.6×10^7 Bq for total beta and the amount of radioactivity including tritium was calculated to be approximately 2.8×10^8 Bq.

Regarding the radiation dose on the ground surface before and after excavation and collection of soil, the effective dose due to gamma rays dropped from 0.18 mSv/h to 0.016 mSv/h, and the equivalent dose to the skin due to beta rays dropped from 0.07 mSv/h to 0.00 mSv/h.

Although some of the leaked water permeated the soil, it did not flow outside the wall of sandbags placed around the leakage location. TEPCO therefore concluded that this event caused no ocean contamination that raises any concerns about effects on health or the environment. Also, recovery of the soil that leaked water permeated has been completed.

(2) Investigation of the leakage situation

Before the event occurred, low-temperature conditions persisted inside the lagging material of the differential manometer due to the low outside air temperature (around -6°C) from around 22:00 on 5 February 2014 to around 4:00 on 6 February 2014. Because of this, the RO-treated water inside the differential manometer exposed to outdoor air via the body froze and increased in volume, which led to deformation of the bonnet flange and loosening of the bonnet flange bolts. It is assumed that the bonnet flange thus lost its sealing function and leakage occurred from the seal portion when the frozen RO-treated water melted. Moreover, due to the fact that other instruments having operating temperature ranges similar to that of the relevant instrument (operating temperature range: -5 to 40°C , however, the fluid should not be allowed to freeze) had been used successfully outdoors at Fukushima Daiichi Nuclear Power Station, it was considered sufficient to attach lagging material as a freeze-proofing measure when choosing such an instrument.

(3) Countermeasures

(i) Anti-freezing countermeasures

The entire double strainer, including the differential manometer, was covered with an acrylic cover, and two fan heater units were placed under the cover. As a countermeasure against leakage outside the system, a concrete dike was installed around the double strainer. For instruments installed outdoors or in locations

where it is difficult to isolate them from outdoor air and which contain fluids that may freeze, it was decided to install heaters to prevent freezing or draining of water inside instrument main units and instrumentation piping in the future, and these countermeasures were described in the “Flow chart for the implementation of anti-freezing countermeasures.” A total of 38 instruments (all installed in the stagnant water storage facilities for Units 5 and 6) are subject to the countermeasures based on said flow, and implementation of countermeasures has been completed for 8 of these. Installation of freeze prevention heaters is scheduled to be completed before the onset of winter in FY2014 for the 30 instruments for which countermeasures have not yet been implemented.

- (ii) Establishment of the “Flow chart for the implementation of anti-freezing countermeasures” as a manual

The “Flow chart for the implementation of anti-freezing countermeasures” will be included among the “Anti-freezing countermeasures operation guidelines” scheduled to be established in November 2014 as lower-tier documents in the Basic Manual for Decommissioning and Basic Manual for Maintenance Management.

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

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

Based on the fact that the leaked RO-treated water (radioactivity concentration: approx. 9.3×10^4 Bq/L for total beta, approx. 3.8×10^5 Bq/L for tritium) remained within the sandbag wall placed around the leakage location and no contaminated water was observed flowing outside the sandbag wall, so 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

An evaluation of the effective dose due to gamma rays and the equivalent dose to the skin due to beta rays for workers who patrolled the area where the differential manometer was installed showed no significant differences between the values before and after discovery of the leakage. The NRA therefore concludes that there has been no exposure leading to concern (refer to Table 1).

(3) Countermeasures

TEPCO determined the assumed cause from the obtained information and formulated anti-freezing countermeasures based on this cause. The NRA has evaluated them as follows, countermeasures summarized by TEPCO shall be checked about its implementation situation at an appropriate timing by safety inspection, etc.

(i) Anti-freezing countermeasures

Based on the “Flow chart for the implementation of anti-freezing countermeasures,” it was decided to install freeze prevention heaters and drain the water inside the main units and piping of instruments for which countermeasures were deemed necessary, and these countermeasures were described in the flow chart.

The report stated that installation of freeze prevention heaters was scheduled to be implemented before the winter of FY2014 for the 30 instruments for which countermeasures had not yet been implemented among those subject to the “Freeze prevention countermeasures implementation flow” (38 instruments in total; all are installed in the stagnant water storage facilities for Units 5 and 6). The NRA has confirmed in a meeting with TEPCO that implementation of the countermeasures was completed on 28 November 2014.

TEPCO has analyzed the causes of the leakage and taken its measures responding to them appropriately, the NRA thus considers them reasonable.

(ii) Establishment of the “Flow chart for the implementation of anti-freezing countermeasures” as a manual

The report stated that the “Flow chart for the implementation of anti-freezing countermeasures” would be included in the “Anti-freezing countermeasures operation guidelines” scheduled to be established in November 2014 as lower tier documents in the Decommissioning Basic Manual and Maintenance Management Basic Manual. The NRA has confirmed in a meeting with TEPCO that the guidelines were established on 27 November 2014 and came into force on 1 December 2014.

The relevant guideline states: “For instruments installed outdoors or in locations where it is difficult to isolate them from outdoor air and which contain fluids that

may freeze, install heaters to prevent freezing and drain the water inside such instrument main units and instrumentation piping in the future.”

TEPCO has analyzed the causes of the leakage and taken its measures responding to them appropriately, the NRA thus considers them reasonable.

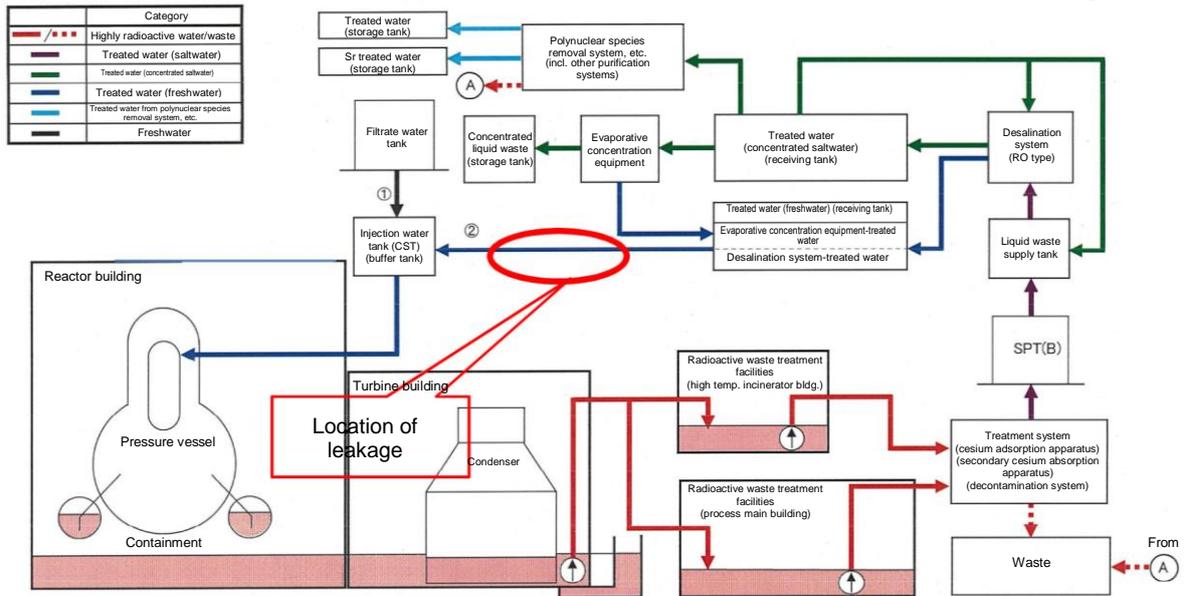


Figure 1 Overview of the processing route for accumulated highly radioactive water (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

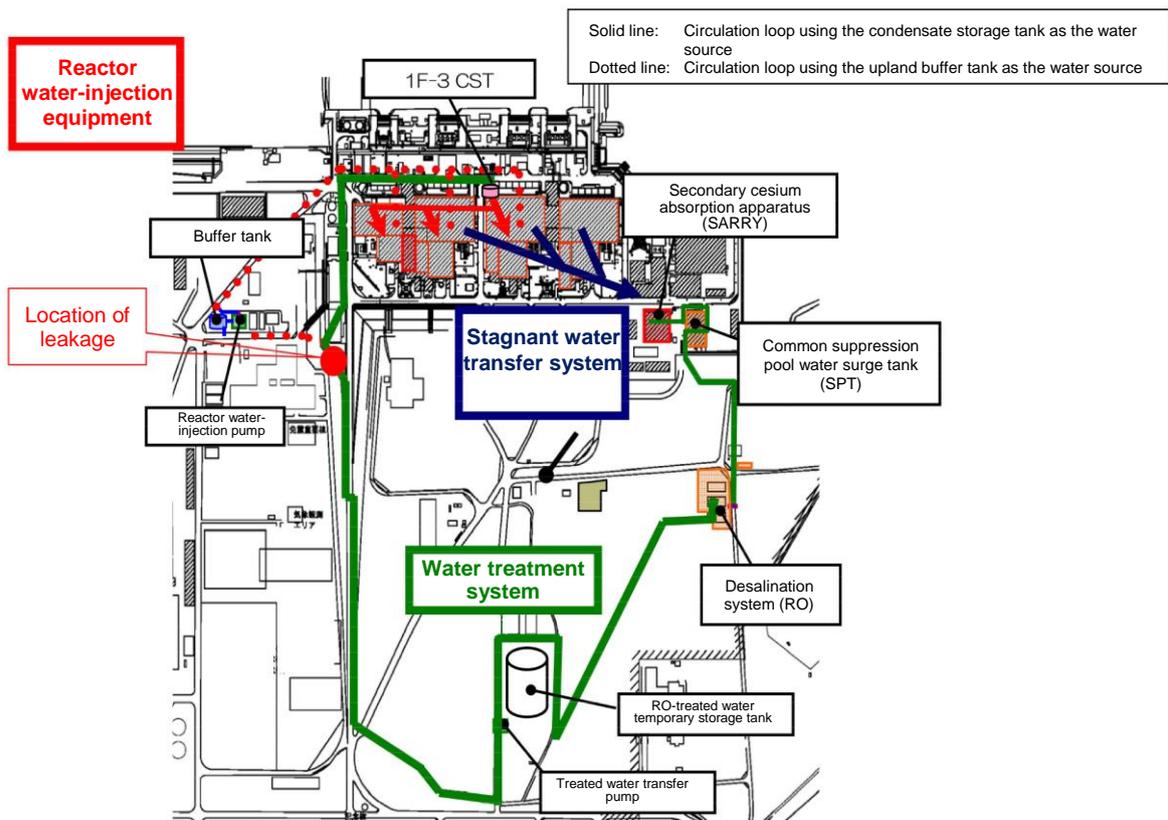
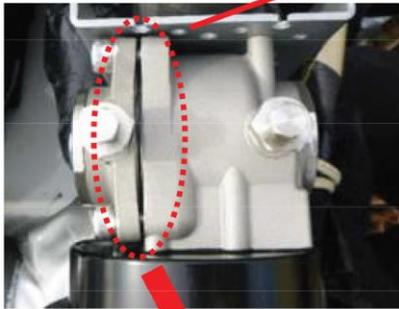


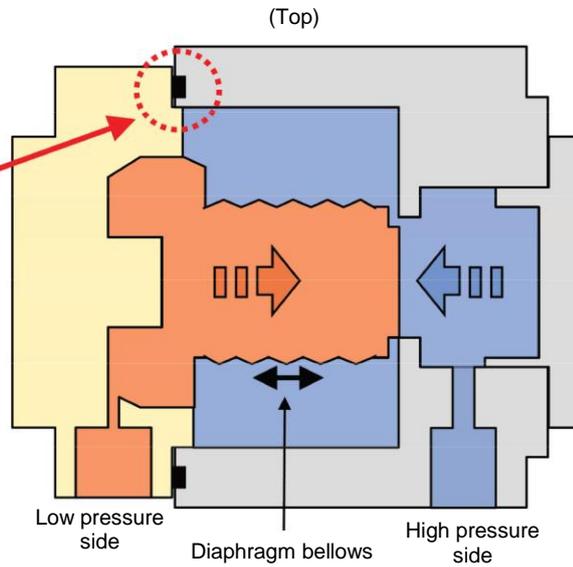
Figure 2 Approximate position of the leakage (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)



External appearance of the affected differential manometer
 Note: No traces of damage (scratches, deterioration, etc.) on its exterior



Condition of the bonnet flange (top)
 Note: The flange is slightly swollen and the O-ring is projecting out of the flange.



Overview of the affected differential manometer

The portion shaded orange (low pressure side) and the portion shaded blue (high pressure side) are filled with water, and the diaphragm bellows expands or contracts due to each portion's water pressure, causing the differential manometer to output a value.



Reading of the affected differential manometer when leakage occurred
 Note: The indicator is off the scale.

Figure 3 Overview of the differential manometer (extracted from the TEPCO report)

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]
Patrols of the area where the differential manometer is installed (including patrols that also include other areas)				
Before finding leakage (30 Jan.–5 Feb.)	0.07	0.21	0.15	1.2
On the day the leakage was found (6 Feb.)	0.04	0.11	0.02	0.1
After finding leakage (7–13 Feb.)	0.04	0.19	0.01	0.1

Table 2 Content and completion time of countermeasures (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

Category	Countermeasure	Date completed
Anti-freezing countermeasures	Replacement of the affected differential manometer with a new product	9 April 2014
	Installation of an overall cover (acrylic) and fan heaters (2 units)	17 June 2014
	Replacement of the sandbag wall placed around the double strainer differential manometer with a concrete dike	23 June 2014
	Installation of freeze prevention heaters and draining of the water inside instruments for Units 5 and 6 (30 locations)	28 November 2014
Establishment of the “Flow chart for the implementation of anti-freezing countermeasures” as a manual	Revision of the “Flow chart for the implementation of anti-freezing countermeasures”	4 September 2014
	Formulation of the “Flow chart for the implementation of anti-freezing countermeasures”	27 November 2014