# Evaluation of the report of Tokyo Electric Power Company regarding the leakage from the 4000-t square steel tank cluster at the Fukushima Daiichi Nuclear Power Station

28 April 2015
Nuclear Regulation Authority, Japan

## 1. Overview

Around 14:00 on 2 June 2014, a nuclear safety inspector patrolling the site found water leaking from portions around bolts (refer to Figures 2 and 3) attached to the upper parts of the sides of two tanks (Nos. 1-3 and 1-5, 35 $m^3$ tanks) of the 1000 t square steel tank (hereinafter, referred to as "notch tank") cluster, which is part of the 4000 t notch tank cluster* (refer to Figure 1).

Despite the fact that the leaking water was dripping into a dike, the dike's drain valve remained open. Tokyo Electric Power Company (hereinafter, referred to as "TEPCO") measured the radiation dose (70 μm dose equivalent rate (β rays)) on the ground around the drain valve and outside the dike, finding a maximum radiation dose of 0.028 mSv/h within the area up to a distance of approximately 40 m from the drain valve. TEPCO therefore concluded that water in the tanks leaked outside the dike (refer to Figure 4).

On 9 June 2014, 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 17 December 2014 (partially corrected on 20 April 2015) and the NRA reviewed the contents and summarized the evaluation result.

Report from TEPCO
https://www.nsr.go.jp/activity/bousai/trouble/20141217-3.html

* The notch tank cluster is used for temporary storage of rainwater accumulated in the dike located in the contaminated-water tank area. This cluster is composed of multiple notch tanks connected to one another with hoses. It consists of two clusters installed in different locations: a 1000-t notch tank cluster (2× 110-$m^3$ tanks, 24×42-$m^3$ tanks, and 24× 35-$m^3$ tanks; total capacity of 2,068 $m^3$) and a 3000-t notch tank cluster (4 ×110-$m^3$ tanks, 32× 42-$m^3$ tanks, and 31× 35-$m^3$ tanks; total capacity of 2,869 $m^3$).

Around October 2013, rainwater accumulated in the dike located in the contaminated-water tank area, including the H4 north area was transferred to the 1000-t notch tank cluster, where the leaking tanks were found. No other transfer has been performed since October 2013. Radioactive concentrations in the

rainwater accumulated in the dike portion located in the H4 north area were $5.1 \times 10^5$ Bq/L for all total beta; 40 Bq/L for Cs-134; 120 Bq/L for Cs-137 as of 20 October 2013..

## 2. Overview of the report submitted by TEPCO

(1) Result of environmental impact assessment (expansion of contaminated water)

The amount of leakage from the tanks was estimated to be approximately 4 $m^3$ based on the presumed first date of leakage and dripping amount; the amount of leakage outside the dike was estimated to be approximately 3.5 $m^3$ based on the analysis of the radioactive concentration in the water accumulated in the dike. The r radioactive concentration was estimated to be $7.2 \times 10^4$ Bq/L for total beta (the radioactive concentrations for Cs-134 and Cs-137 were lower than detection limits) from the analysis results, and the amount of radioactivity was estimated to be approximately $2.5 \times 10^8$ Bq for total beta.

Although part of the leaked water permeated into the soil, it spread only within a limited area and did not reach the areas near the side ditches. It was therefore concluded that no ocean contamination occurred. The leaked water and contaminated soil have been collected.

(2) Causes

While storing water, the tanks swelled in the middle of the upper-end part of their side panels. This swelling caused gaps (openings) to develop between the tanks' top panels and hanging metal attached to the upper end of the tanks' top panels (refer to Figure 5).

Rainwater entered the tanks through these openings that had formed at the tanks' top panels, gradually leading to an increase in the water level of the 1000 t notch tank cluster. As a result, stored water leaked into the dike from the portions around the bolts, which had low cut-off performance.

The causes of leakage outside the dike were as follows.

a. The drain valve, which remained open, allowed stored water that leaked into the dike to further leak outside the dike.

b. No patrol was performed around the notch tank cluster, and thus the leakage from the portions around the bolts was not discovered.

(3) Countermeasures

a. Countermeasures against increases in the water levels of the affected tanks

- The 1000 t notch tank cluster stores rainwater accumulated in the dike located in the contaminated-water tank area. The amount of stored water shall be reduced by transferring it to the turbine buildings.

- Operation of rainwater treatment equipment started on 12 May 2014. The amount of water transferred to the notch tank cluster shall be reduced by using this equipment to treat rainwater accumulated in the dike located in the contaminated-water tank area.

- Covers shall be installed over the notch tank cluster to prevent rainwater from entering the openings along tanks' top panels and to prevent rainwater accumulation from increasing in the dike for the notch tank cluster.

- Inspections shall be carried out on the notch tank cluster once a week to confirm that tanks' water levels do not exceed the reference upper limit (approximately 20 cm below the tanks' top panels).

b. Countermeasure to ensure the dike drain valves are closed

- All drain valves of dikes in the notch tank cluster shall remain "closed." Rules regarding this operation shall be stipulated in company manuals.

c. Countermeasure to improve patrol activities (no patrol had been performed)

- Patrols shall be performed for the notch tank cluster once a day to check for leakage and to inspect the conditions of dike drain valves. Rules regarding periodic inspection patrols for the notch tank cluster, including the aforementioned daily patrol, shall be established and stipulated in company manuals.

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

(1) Environmental impact (expansion of contaminated water)

There is no obvious fluctuation in the results of monitoring before and after the leakage occurred in the vicinity of the 35 m board outlet (C-2) of the C drainage ditch and the vicinity of the south discharging outlet (T-2). The NRA therefore concludes that this event did not cause ocean contamination that raises any concerns about effects on health or the environment (refer to Figure 6).

(2) Exposure radiation dose

The effective dose caused by gamma rays and equivalent dose to skin caused by beta rays were evaluated for workers who patrolled the notch tank area (refer to Table 1).

The effective dose and equivalent dose to skin were both well below the annual limits on exposure (50 mSv for effective dose and 500 mSv for equivalent dose). The NRA therefore concludes that there has been no exposure leading to concern.

(3) Countermeasures

The NRA performed safety inspections and other checks to confirm TEPCO's progress in implementing countermeasures formulated by considering the causes of this event (refer to Table 2). The NRA also held a meeting to confirm that TEPCO will install rainwater treatment equipment and water-receiving tanks to replace the 4000 t notch tank cluster, which will be removed.

The NRA thus concludes that the countermeasures formulated by considering the causes have been appropriately implemented and countermeasures summarized by TEPCO shall be checked about its implementation situation at an appropriate timing by safety inspection, etc.

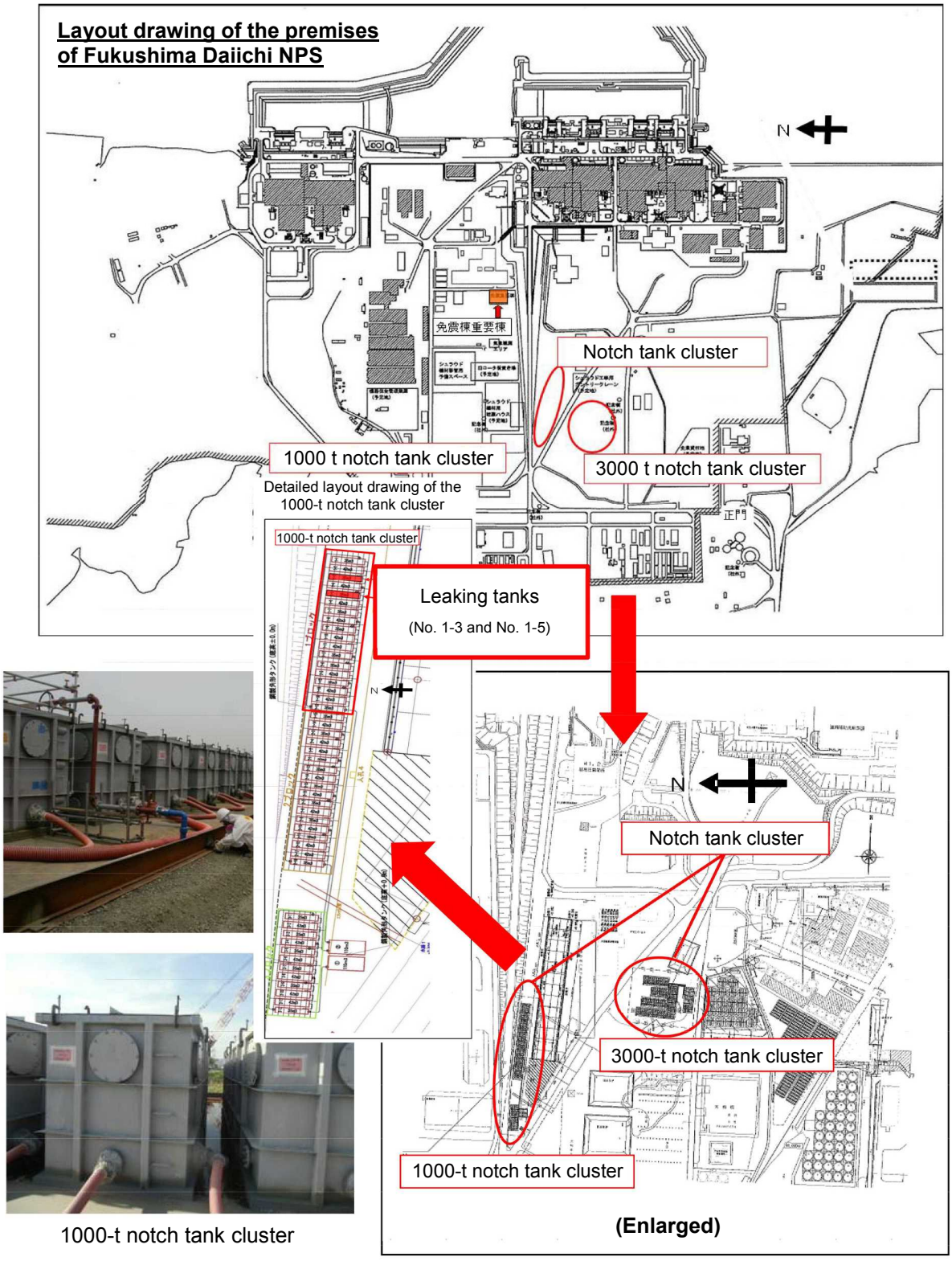



**Figure 1 Layout of the notch tank cluster (extracted from the TEPCO report)**

Leakage event found during a patrol of the 4000-t notch tank cluster

2 June 2014
Fukushima Daiichi NRA Regional Office

1. Time/date and location

   Time/date: From 13:10 to 14:00, 2 June 2014
   Location: 4000 t notch tank cluster

2. Results of checking the site

   The 4000-t notch tank cluster stores rainwater accumulated in dikes when such rainwater does not satisfy the discharge criteria. A patrol was performed to inspect the tank cluster as part of a periodic patrol by a nuclear safety inspector.

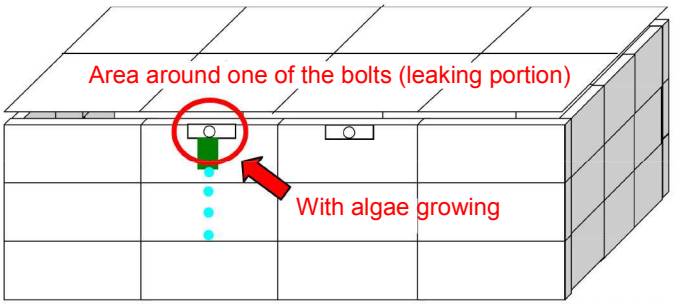
   In the area concerned, water was observed to be dripping from portions around the bolts attached near the top panels of two tanks. The dripping rate was approximately one drop per second. We notified the electric utility of this event and ordered them to check the details.

Photograph 1 Leaking notch tank

Photograph 2 Leaking portion

Photograph 3 Leaking portion

**Figure 2 Tank leakage (report by the Fukushima Daiichi NRA Regional Office's safety inspector)**




Leakage from tank No. 1-3

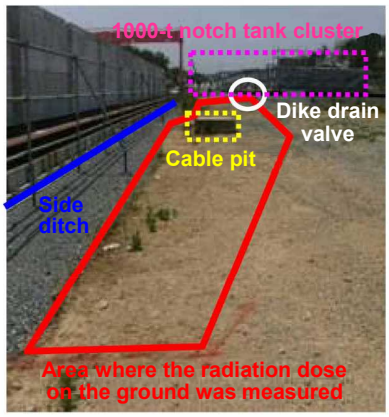
Leakage from tank No. 1-5

Vinyl bag attached to hold leaking water

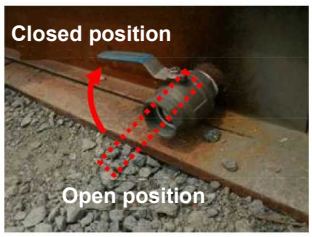
Rainwater accumulated in the dike

**Figure 3 Tank leakage (extracted from the TEPCO report)**

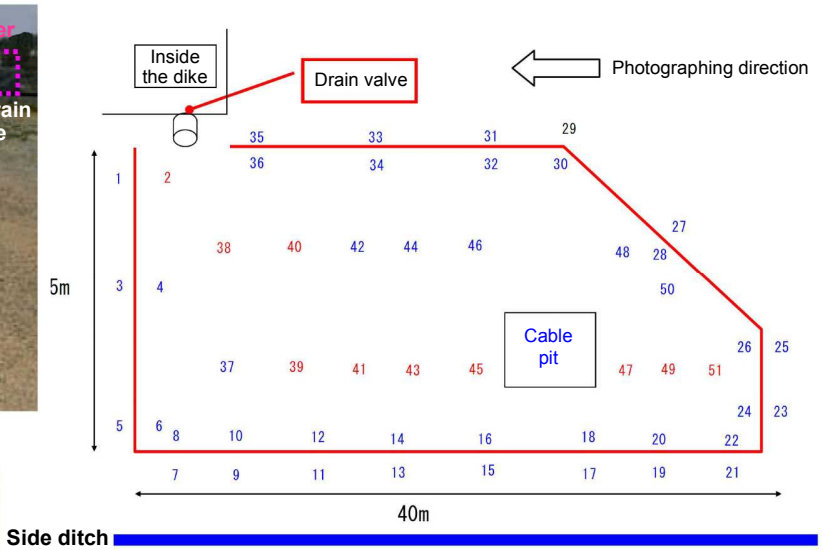
Leakage to outside the dike




Area outside the dike




Dike drain valve
(in the closed position)




Radiation dose measurement points on the ground outside the dike

Result of radiation dose measurement on the ground outside the dike

Measurement date: 4 June 2014

Unit: mSv/h

| Measurement location | 1 cm dose equiv. rate by gamma rays | 70 μm dose equiv. rate by beta rays |
|---|---|---|
| 1 | 0.010 | 0.000 |
| 2 | 0.010 | 0.015 |
| 3 | 0.007 | 0.000 |
| 4 | 0.007 | 0.000 |
| 5 | 0.008 | 0.000 |
| 6 | 0.008 | 0.000 |
| 7 | 0.007 | 0.000 |
| 8 | 0.007 | 0.000 |
| 9 | 0.008 | 0.000 |
| 10 | 0.008 | 0.000 |
| 11 | 0.005 | 0.000 |
| 12 | 0.005 | 0.000 |
| 13 | 0.005 | 0.000 |
| 14 | 0.005 | 0.000 |
| 15 | 0.005 | 0.000 |
| 16 | 0.005 | 0.000 |
| 17 | 0.007 | 0.000 |
| 18 | 0.007 | 0.000 |
| 19 | 0.005 | 0.000 |
| 20 | 0.005 | 0.000 |
| 21 | 0.004 | 0.000 |
| 22 | 0.004 | 0.000 |
| 23 | 0.005 | 0.000 |
| 24 | 0.005 | 0.000 |
| 25 | 0.006 | 0.000 |

| Measurement location | 1 cm dose equiv. rate by gamma rays | 70 μm dose equiv. rate by beta rays |
|---|---|---|
| 26 | 0.006 | 0.000 |
| 27 | 0.006 | 0.000 |
| 28 | 0.006 | 0.000 |
| 29 | 0.006 | 0.000 |
| 30 | 0.006 | 0.000 |
| 31 | 0.004 | 0.000 |
| 32 | 0.004 | 0.000 |
| 33 | 0.005 | 0.000 |
| 34 | 0.005 | 0.000 |
| 35 | 0.004 | 0.000 |
| 36 | 0.004 | 0.000 |
| 37 | 0.007 | 0.000 |
| 38 | 0.007 | 0.018 |
| 39 | 0.004 | 0.006 |
| 40 | 0.004 | 0.006 |
| 41 | 0.004 | 0.016 |
| 42 | 0.008 | 0.000 |
| 43 | 0.007 | 0.028 |
| 44 | 0.007 | 0.000 |
| 45 | 0.006 | 0.006 |
| 46 | 0.006 | 0.000 |
| 47 | 0.005 | 0.007 |
| 48 | 0.004 | 0.000 |
| 49 | 0.006 | 0.004 |
| 50 | 0.008 | 0.000 |
| 51 | 0.006 | 0.004 |

**Figure 4 Data on leakage outside the dike (extracted from the TEPCO report)**

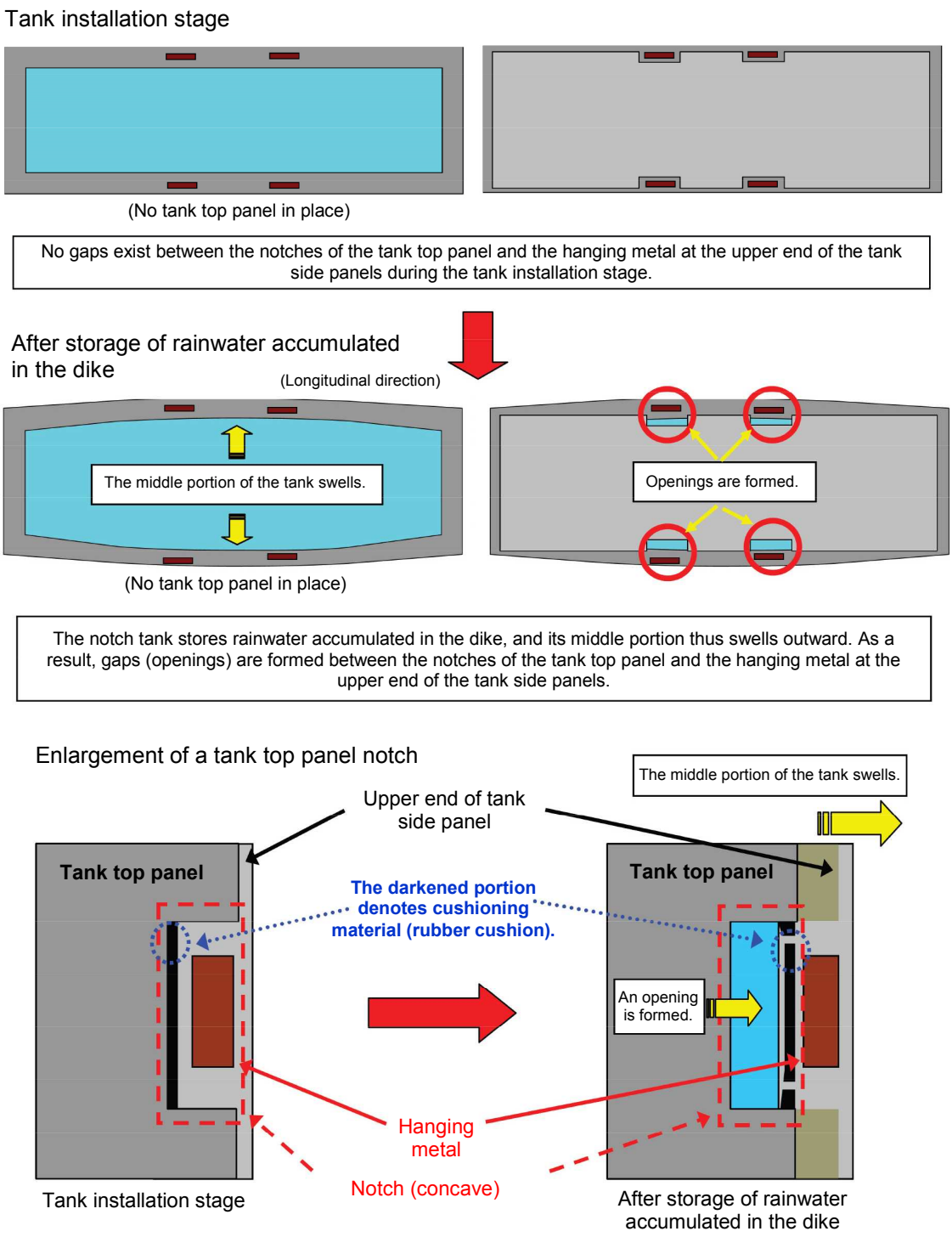



**Figure 5 Formation of an opening at a notch tank top panel (extracted from the TEPCO report)**

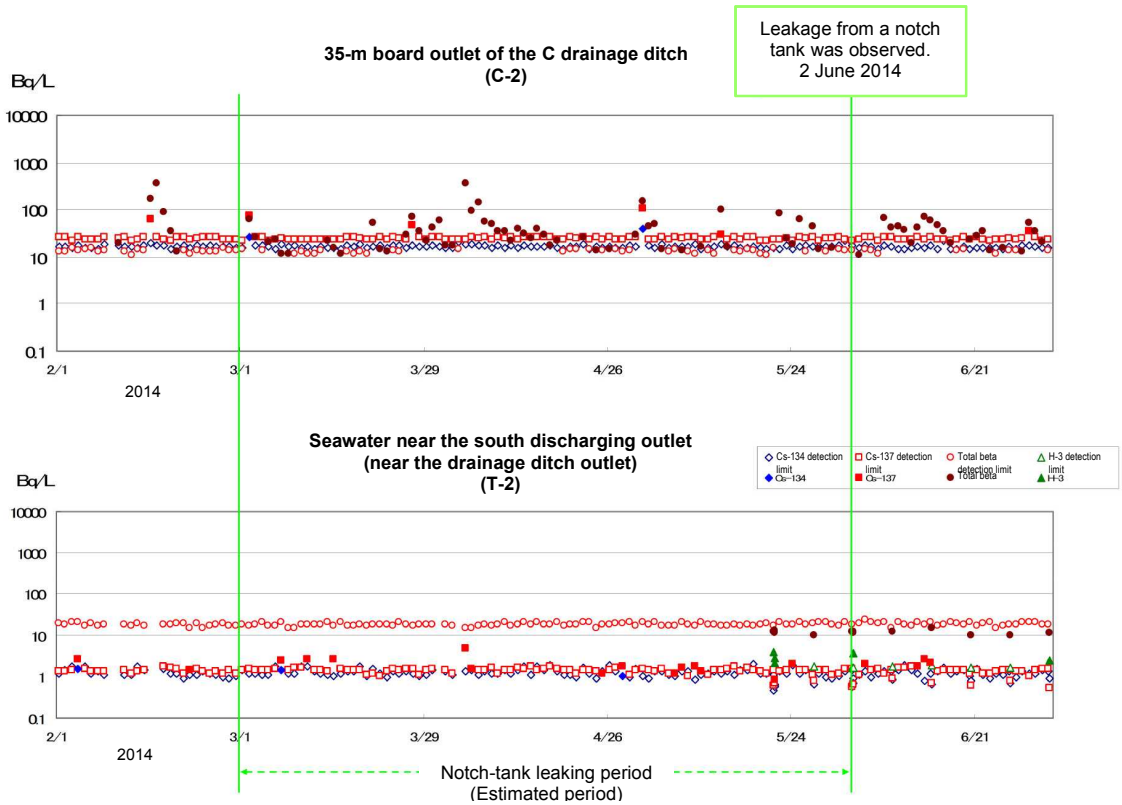



**Figure 6 Results of drainage-ditch and ocean monitoring (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)**

**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 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 patrols | | | | |
| After finding leakage (5–11 June) | 0.01 | 0.04 | 0.00 | 0.0 |

## Table 2 Progress in implementing countermeasures against tank leakage (extracted from the Secretariat of the NRA's document for a meeting with TEPCO)

| | Countermeasure | Date completed |
|---|---|---|
| Countermeasures against increases in water level of the affected tanks | Water shall be transferred to the turbine buildings. | 9 July 2014 |
| | The transfer amount (accepted amount) shall be reduced using rainwater treatment equipment. | 12 May 2014 |
| | Covers shall be installed over the notch tank cluster. | 5 July 2014 |
| | Tank water levels shall be checked once a week. | 16 June 2014 |
| Countermeasure to ensure the dike drain valves are closed | Dike drain valves shall be kept closed. | 2 June 2014 |
| | Rules for keeping dike drain valves closed shall be stipulated in company manuals. | 1 October 2014 |
| Countermeasure to improve patrol activities (no patrol had been performed) | A daily patrol shall be performed for the notch tank cluster. | 5 June 2014 |
| | Rules for inspection patrols for the notch tank cluster shall be stipulated in company manuals. | 4 June 2014 |