

Evaluation of the report by Tokyo Electric Power Company regarding the leakage from a connection valve between A5 tank and A6 tank in the G4 South Tank Area at the Fukushima Daiichi Nuclear Power Station

Nuclear Regulation Authority, Japan
17 June 2015

1. Overview

At 12:04 on 4 September 2014, while transferring contaminated water treated by a desalination device (hereafter, referred to as “RO-concentrated water”) from A4 tank to A5 tank in the G4 South Area, it was found that the water was leaking at a rate of about one drop per second from the valve box of a connection valve (hereafter, referred to as “the Valve”) between A5 tank and A6 tank (refer to Figure 1). The transfer procedure to A5 tank was stopped to inspect the Valve by removing its thermal insulator. A 10-cm crack was found on the Valve box, and water was seeping from around the crack and at the flange. In response, the leaking points were covered with a plastic bag (refer to Figure 2). In addition, water was transferred back from A5 tank to A4 tank starting from 14:43, and adhesive was applied to the leaking points and flanged area, whereupon the leakage stopped at 18:03.

It was assessed that approximately one liter of water had leaked and that the amount of radiation was approximately 2.7×10^4 Bq for total γ nuclides, and approximately 9.8×10^7 Bq for total β nuclides. The leaked water remained in the dike surrounding the G4 South Tank Area, and no leak out of the dike was found. This remaining water was recovered with a suction vehicle on 4th to 6th of September and the dike floor was cleaned.

On 17 September 2014, Tokyo Electric Power Company (hereinafter, referred to as “TEPCO”) reported this event to the Nuclear Regulation Authority (NRA), pursuant to Article 62-3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, which requires operators to report certain accidents and failures to the NRA.

The NRA subsequently received a final report regarding the causes and countermeasures of the aforementioned event from TEPCO on 28 April 2015 (partially corrected on 5 June 2015), whereupon the NRA reviewed the contents and summarized the evaluation result.

Report from TEPCO:

https://www.nsr.go.jp/activity/bousai/trouble/houkoku/2015_06_05.html

2. Overview of the report submitted by TEPCO

(1) Assessment of the impact on the environment (spread of the contaminated water)

The amount of leakage from the Valve was estimated at approximately one liter based on the rate (approximately one drop per second) and presumed duration of the leak. The leakage was presumed to have started at 11:00 on 4 September, when the transfer of RO-concentrated water from A4 tank to A5 tank, to which the Valve was installed, was started, until 12:15 on the same day when the leakage was stopped by covering the points of leakage with a plastic bag. The concentration of radioactivity in the sample of the leaked water was analyzed as approximately 2.5×10^3 Bq/L for ^{134}Cs , approximately 7.3×10^3 Bq/L for ^{137}Cs , approximately 1.7×10^4 Bq/L for ^{125}Sb , and approximately 9.8×10^7 Bq/L for total β nuclides. From these results, the amount of radioactivity was estimated at approximately 2.7×10^4 Bq for total γ nuclides and approximately 9.8×10^7 Bq for total β nuclides

The leaked water remained in the dike around the G4 South Tank Area, no leak out of the dike was found. The leaked water that remained in the dike was subsequently collected. It was therefore concluded that no contamination to the environment had occurred.

(2) Causes

It was found that the Valve was closed during a draining of the connection pipes following a water-filling test for A5 and A6 tanks in November 2013. As a result, the sealed chamber remained filled with filtered water (refer to Figures 3 and 4). Despite the fact that thermal insulators were installed to the Valve and the connection pipe, due to the close proximity of the Valve to the A5 tank, they were virtually exposed to outside air via the tank (refer to Figure 4).

The number of days when the minimum temperature of the outside air within the Nuclear Power Station site marked below-freezing points between late December 2013 and the end of March 2014 amounted to 61 days, out of which 4 days recorded -5°C or lower. Notably, from around 22:00 5 February 2014 to around 5:00 the next morning, the outside air temperature was constantly -5°C or lower. Because of such low temperatures, it is presumed that the sealed chamber of the Valve cooled from the inside, and the filtered water remaining inside the sealed chamber froze and its increased volume caused the through crack.

On 4 September 2014, while the RO-concentrated water was being transferred to A5 tank, the water leaked from the through crack of the Valve.

The manufacturer of the Valve investigated past similar incidents, and as a result, found an incident where liquid remaining in the sealed chamber inside the Valve box froze and its increased volume applied excessive stress that generated a crack. A valve of the same type with its sealed chamber full of water was tested by leaving it at an ambient temperature of -10°C . When the temperature on the surface of the Valve box reached approximately -5°C (around 6 hours and 20 minutes from the start of the test), a crack resembling the through crack which caused this incident appeared (refer to Figure 5).

(3) Countermeasures

a. Replacement of the Valve that produced the through crack

The Valve that produced the through crack was replaced with another valve of the same type on 13 September 2014. The same type of valves on the RO-concentrated water lines outside the dikes and inside the dikes of contaminated water tanks was visually inspected by removing thermal insulators from 26 September to 13 November 2014, and no problems were found.

b. Announcement of new procedures to be included in the Testing and Construction Work Manual

Related departments were instructed to inscribe in their Testing and Construction Work Manual, the procedures for draining the sealed chamber of valves when draining the connection pipes after conducting water filling tests for contaminated water tanks and connection pipes.

c. Revision of the Implementation Guidelines for Freeze Prevention Measures

To ensure that measures are taken for similar valves, which have sealed chambers, the outline of this incident was included in *the Implementation Guideline for Freeze Prevention Measures*, one of the TEPCO's guidelines, which was set on 27 November 2014. The guideline instructs the selection of those pieces of equipment that require freeze prevention measures. The revision also specified the removal of remaining water annually in accordance with the flow chart for implementing freeze prevention measures that apply to equipment containing water (such as filtered water or contaminated water) and equipment that contained water in the past (refer to Figure 6).

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

(1) Environmental impact (spread of contaminated water)

Although approximately one liter of RO-concentrated water leaked through the Valve flowed to the dike around the G4 South Tank Area, the NRA concludes that no water leakage out of the dike was found, based on the reasons listed below.

- No change was observed in rainwater levels in the dike before and after the incident was found.
- The G4 South Area patrols left no record that indicates water leaking out of the dike.
- Both of the two pipe penetrating areas in the dike are located at points higher than 50 cm, which is sufficiently higher than the water level in the dike (which was approximately 3 cm when the incident occurred).
- The dike has no valves for discharging the water in the dike.
- The water that remained in the dike was collected with a suction vehicle and the dike floor was cleaned.

(2) Exposure radiation dose

The effective dose caused by γ rays and the equivalent dose to skin caused by β rays were evaluated for the workers who patrolled the G4 South Area and the workers who conducted the transfer of RO-concentrated water (refer to Table 1). The effective dose and equivalent dose to the skin were both well below the annual limits of exposure (50 mSv for effective dose and 500 mSv for equivalent dose to the skin). Therefore, the NRA concludes that there has been no exposure that warrants concerns.

(3) Countermeasures

TEPCO had completed implementing countermeasures based on the causes of the incident by 15 May 2015 (refer to Table 2). The NRA gives its conclusions as shown below, and progress in implementing the countermeasures shall also be verified by safety inspections and other means as necessary.

- a. Replacement of the Valve that produced the through crack

The Valve was replaced with a new valve of the same type. The NRA concludes that appropriate measures had been taken, such as the draining procedure shown below for preventing through cracks from occurring due to freezing. In addition, for other valves of the same type, the NRA concludes that appropriate responses were made due to the fact that visual inspections found no problems and it was confirmed that the draining operation of connection pipes had left no water inside the sealed chambers of these valves.

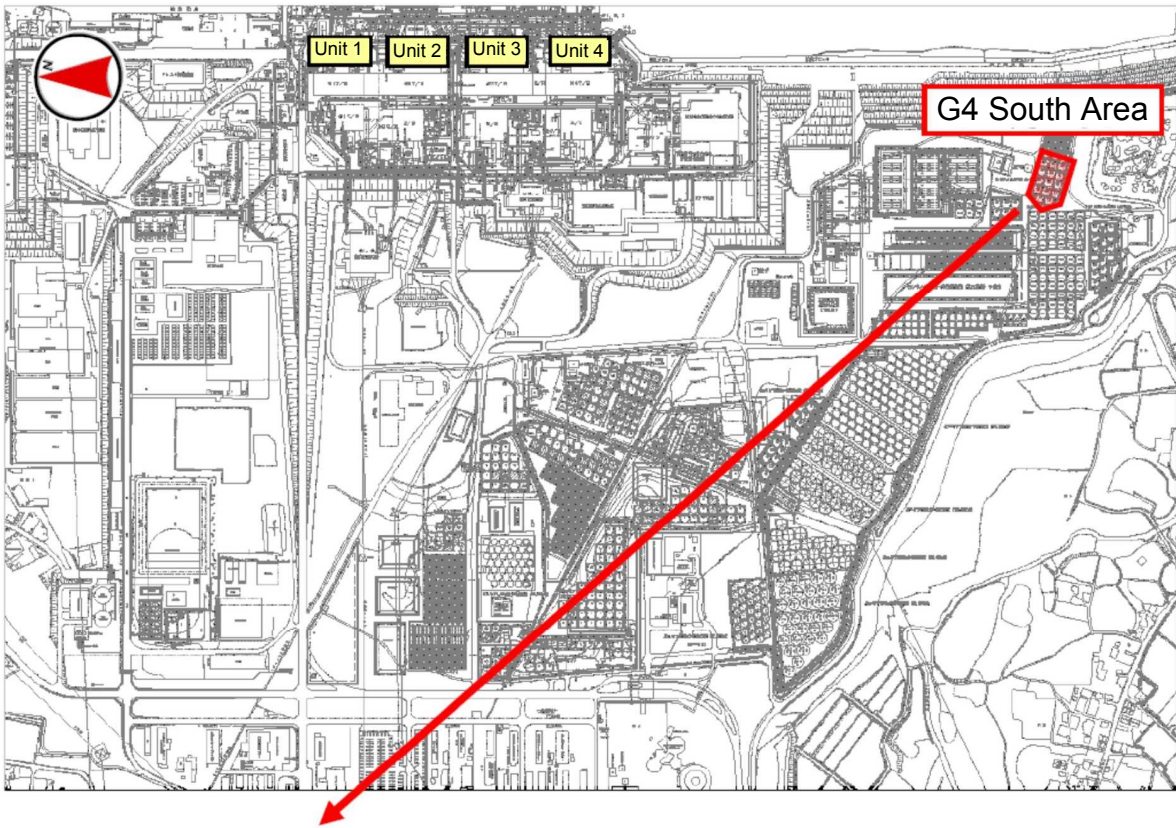
- b. New procedures to be included in the Testing and Construction Work Manual

The NRA concludes that, by stipulating the steps for draining sealed chambers of valves after water-filling tests in the Testing and Construction Work Manual, the risk of generating through cracks due to freezing will be reduced for future installations of connection valves with sealed chambers. The NRA also concludes that appropriate measures have been taken with regards to revising the Testing and Construction Work Manual, in light of the fact that it was announced to the related departments that are in charge of installing, operating, and maintaining equipment that handles water (such as filtered water or contaminated water).

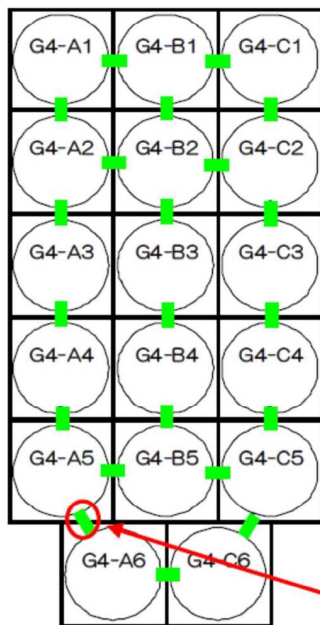
- c. Revision of *the Implementation Guideline for Freeze Prevention Measures*

The NRA concludes that appropriate measures for preventing through cracks from occurring due to freezing were taken. The NRA concludes this in light of the fact that pieces of equipment that require freeze prevention measures will be selected from all pieces of equipment that contained water in the past; moreover removal of remaining water will be conducted annually in accordance with *the Implementation Guideline for Freeze Prevention Measures*.

Map of tank area

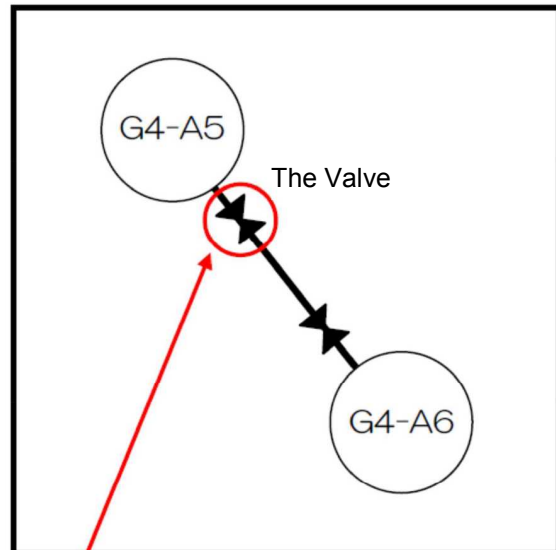


Detail of G4 South Area



— Connection pipe

Location of the Valve



Location of the leakage

Figure 1 Location of the connection valve that caused the leakage (extracted from the TEPCO report)

Appearance inspection results

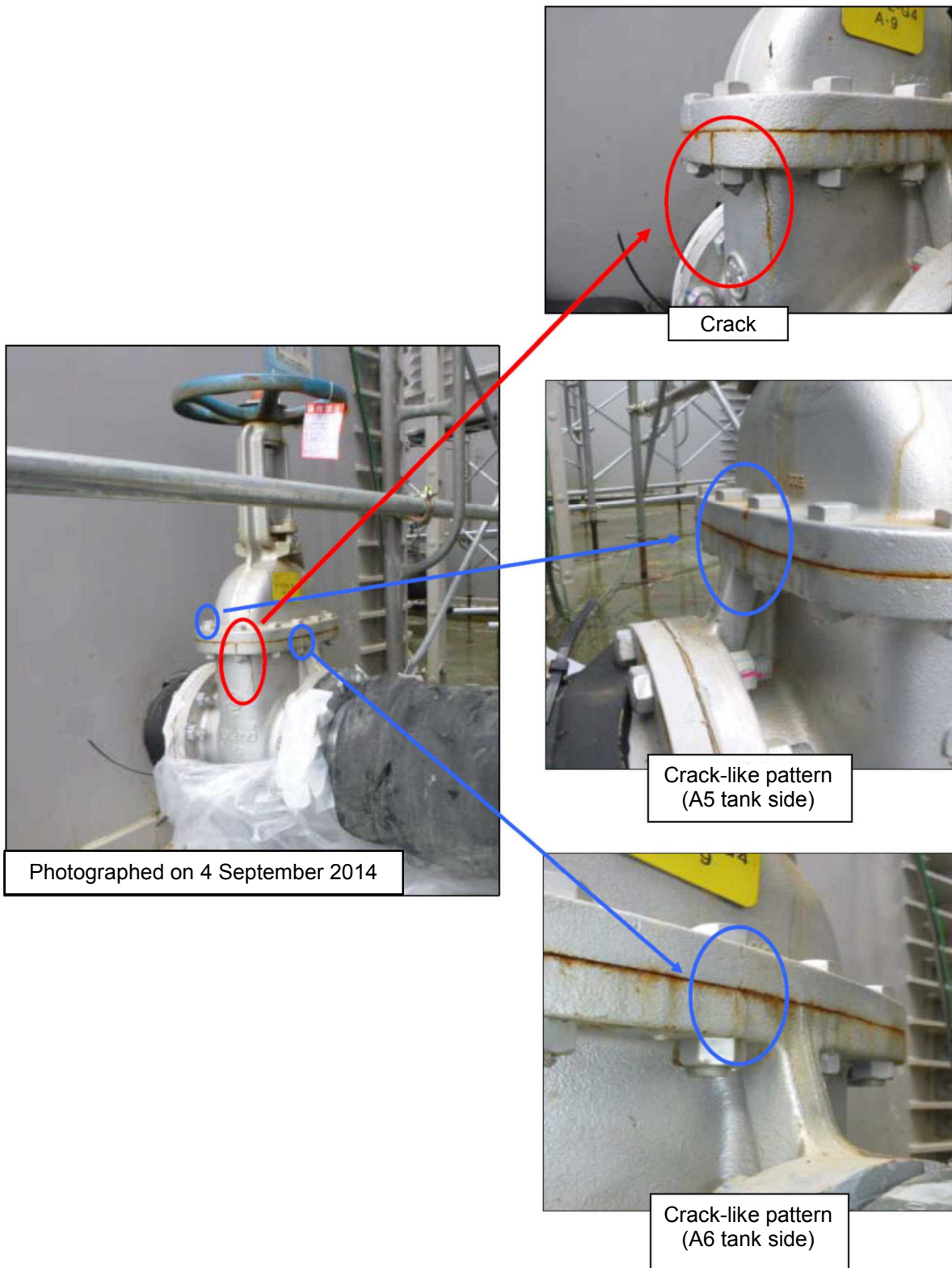
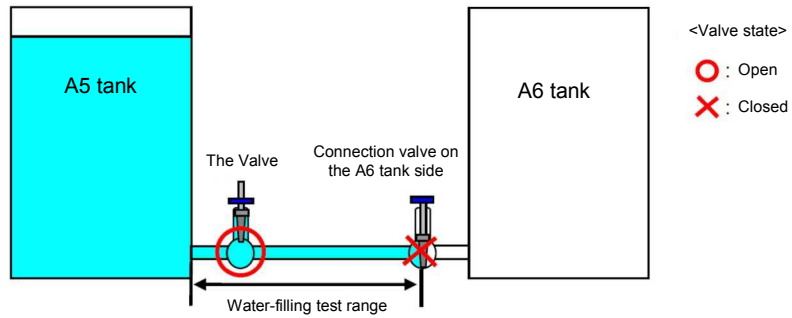
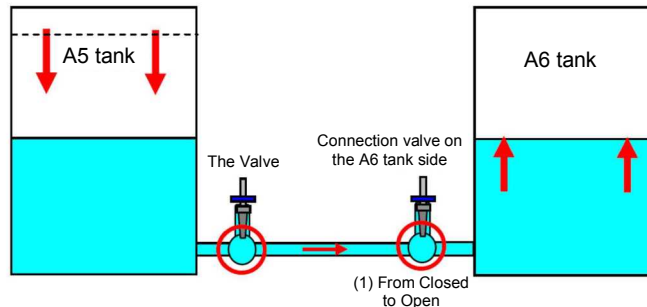


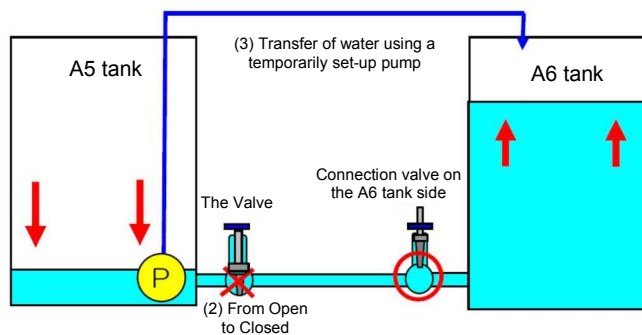
Figure 2 Appearance of the Valve (extracted from the TEPCO report)



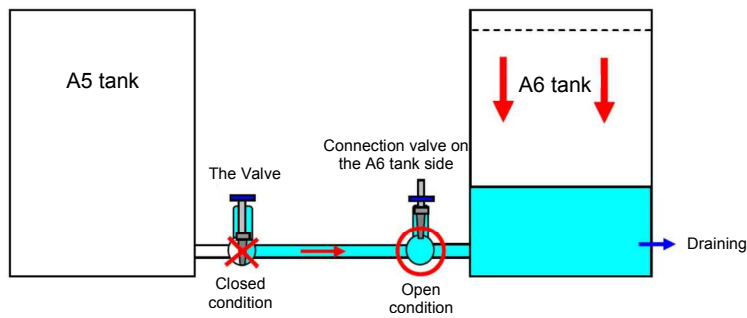
Water-filling test condition of the connection pipes including the Valve (12 to 13 November 2013)



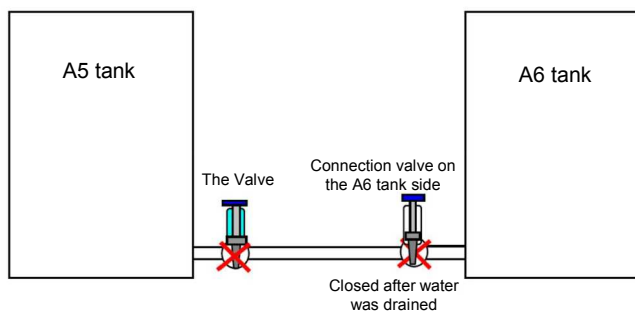
Transfer of filtered water from A5 tank to A6 tank (using water head pressure)



Transfer of water from A5 tank to A6 tank using a temporarily set-up pump



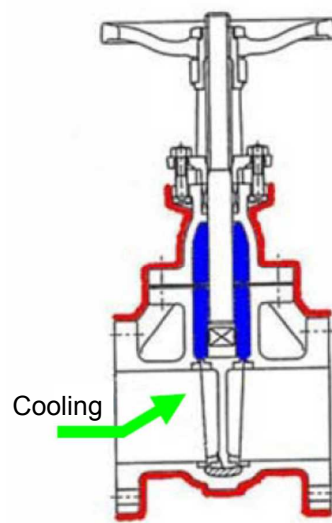
Condition of A6 tank during the draining procedure



Condition of A6 tank after the draining procedure (Filtered water is remaining in the sealed chamber.)

Figure 3 Leakage from tanks (extracted from the TEPCO report)

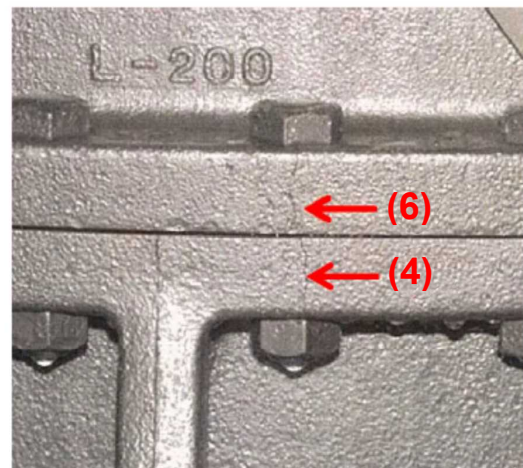
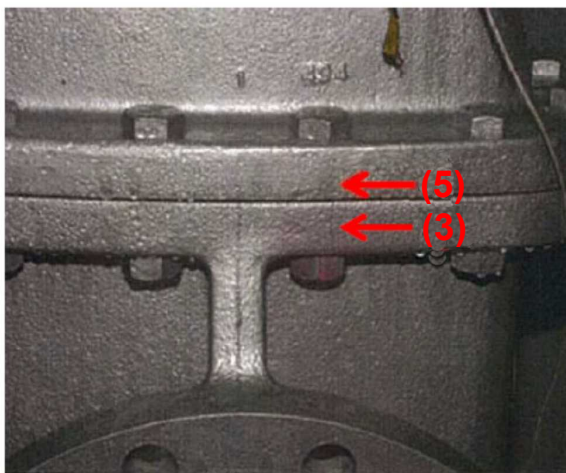
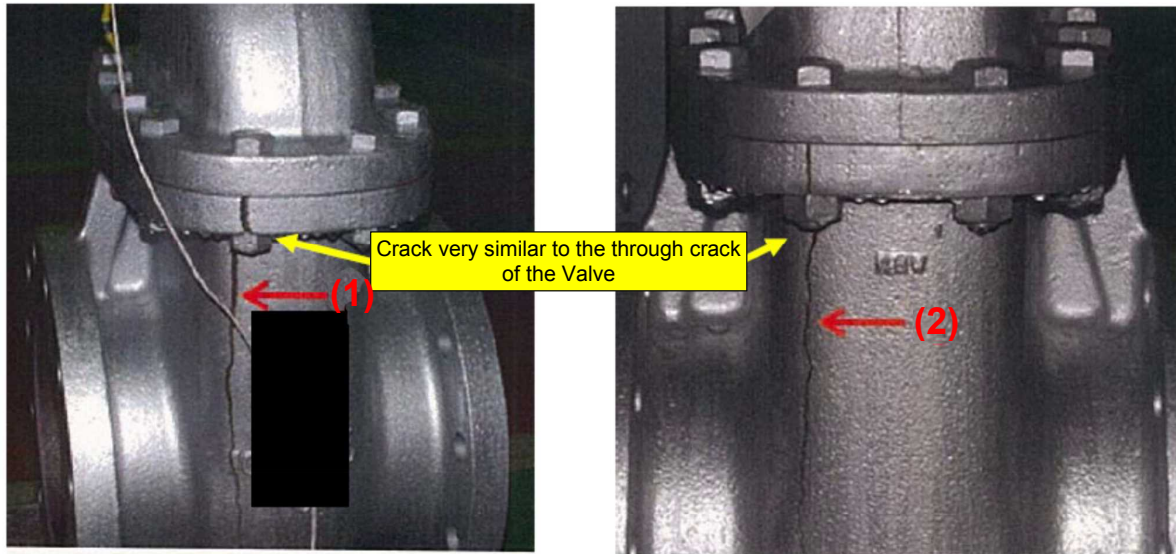
The sealed chamber was exposed to outside air that came in through the air bleeder tube of A5 tank, and the chamber was likely cooled from inside of the valve. Due to this condition, the thermal insulator attached on the outside of the Valve did not work effectively.



■ : Liquid
■ : Thermal insulator

The A6 tank side of this sealed chamber was not directly exposed to outside air because the connection valve on the A6 tank side was in the closed position.

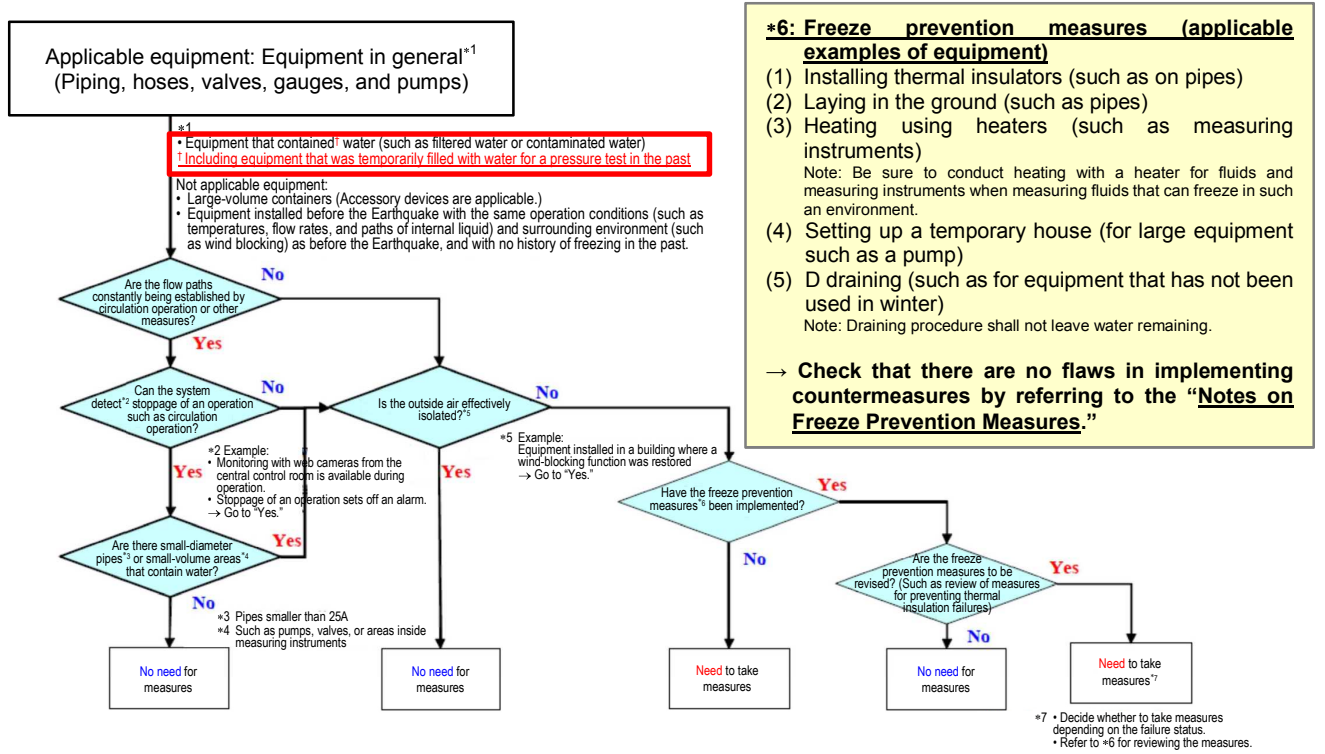
Figure 4 The sealed chamber of the Valve and cooling condition
(extracted from the TEPCO report)



Photographs were provided by the valve manufacturer.

Cracks were found at six points (1) to (6).

Figure 5 Results of a test that reproduced generation of through cracks due to freezing (extracted from the TEPCO report)



† : This point has been reflected in the guidelines as countermeasures for this incident.
(The words in red were added.)

Figure 6 Flow chart for implementing the freeze prevention measures
(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 (γ rays)		Equivalent dose (skin, β 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				
Before finding leakage (28 August to 3 September)	0.01	0.07	0.00	0.0
Day when leakage was found (4 September)	0.01	0.03	0.00	0.0
After finding leakage (5 to 11 September)	0.01	0.08	0.00	0.0
Emergency measures				
Applying adhesive to the Valve Transfer of water from A5 tank to A4 tank	0.03	0.13	0.01	0.1
Transfer of water from A5 tank to A4 tank	0.04	0.06	0.00	0.0
Collecting water remaining the dike; cleaning the dike floor	0.03	0.06	0.00	0.0

Table 2 Progress in implementing countermeasures against problems in the A5–A6 tank connection Valve in G4 South Area
(extracted from the secretariat of the NRA's document for a meeting with TEPCO)

Countermeasures	Date completed
Replacement of the Valve that produced a penetrating crack	13 September 2014
New procedures (draining the sealed chamber) to be included in the test and construction work manual and its notification	15 May 2015
The outline of this incident is to be reflected on the Implementation Guidelines for Freeze Prevention Measures as new experience and knowledge	1 April 2015