Evaluation of the Gamma Ray-emitting Nuclides Analysis at the Fukushima Daiichi Nuclear Power Station

<Reference Information>
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Tokyo Electric Power Company

1. Overview

- At the Fukushima Daiichi nuclear power station, we have been measuring the concentration of radioactivity in dust, seawater, sub-drain and resident water in buildings since the accident. For gamma ray-emitting nuclides, (such as cesium), we have been using germanium (Ge) semiconductor-based detectors[*1].
  Although radioactivity levels around the power station have become lower as a result of the decontamination of the premises of the power station including the inside of buildings of the power station and the radioactivity decay, measurement on samples that require radioactivity concentration measurement at low detection limit levels has been done at the Fukushima Daini and Kashiwazaki Kariwa nuclear power stations, with only high-radioactivity concentration samples being measured at the Fukushima Daiichi nuclear power station.

- This time we performed radioactivity concentration measurement for gamma ray-emitting nuclides (cesium 134 and cesium 137) in the temporary storage tanks of the Fukushima Daiichi nuclear power station to prepare for the future groundwater bypass operation process.
  In conjunction with our presentation about groundwater bypassing-related radioactivity concentration measurement to nuclear operational safety inspectors, they instructed us on May 30 of this year to confirm the shielding effect of the background[*2] (BG) on measurement samples in the results of measurement performed using Ge semiconductor-based detectors as they considered that it was not always negligible.

- To confirm the self-shielding effect on the BG of samples in measurement using a 2-liter Marinelli container[*3], which will be used in our measurement, we checked the BG with no sample present and measured the BG with a blank sample (uncontaminated purified water in a Marinelli container) present, for each of the Ge semiconductor-based detectors of the Fukushima Daiichi nuclear power station.

  We also checked the BG with no sample present and measured the effect of the BG on a blank sample for the 2 Ge semiconductor-based detectors that have been used at the Fukushima Daini nuclear power station. Regarding the Ge semiconductor-based detectors of the Kashiwazaki Kariwa nuclear power station, we confirmed that there was no BG and no shielding effect on the BG.

- Close examination of the measurement results showed that measurement using a Ge semiconductor-based detector of the Fukushima Daiichi nuclear power station on a sample in a Marinelli container would be accompanied by a shielding effect on the BG of the Marinelli container which would alter the measurement result by several Becquerel per liter.

- On the basis of these results, we examined samples that are being analyzed at the Fukushima Daiichi nuclear power station for nuclides emitting gamma ray with relatively low radioactivity concentration, and found that the water in the temporary storage tanks for bypassing groundwater was of relevance. Therefore, we investigated the effect on groundwater bypassing-related measurement results.

- As a result, it was confirmed that there was no effect of self-shielding on the BG in the measurement results for cesium 134 and cesium 137 for the measured pumping wells of the Fukushima Daini and Kashiwazaki Kariwa nuclear power stations.
  For the temporary storage tank (the Gr-A-1 tank), we performed measurement for gamma ray-emitting nuclides at the Fukushima Daiichi nuclear power station and found that the measurement result had been affected by the self-shielding effect. Therefore, we performed the same analysis using a Ge semiconductor-based detector of the Fukushima Daini nuclear power station that was not subject to the self-shielding effect and confirmed that the value was below 1Bq/L, which is the guide maximum allowable value for cesium 137.

*1: Germanium semiconductor-based detector
A radiation detector that uses a germanium semiconductor to identify and quantify gamma ray-emitting nuclides such as iodine 131 and cesium 137 contained in samples.

*2: Background
Radioactivity concentration of natural radiation measured with no measurement subject present.

*3: Marinelli container
A container that is used in the measurement of radiation in water samples and has a large hollow in the bottom to insert the sensor of a germanium semiconductor-based detector.

2. Result of the Analysis for the Temporary Storage Tank for Groundwater Bypassing

(Unit: Becquerel/liter)

Confirmation item / System	Temporary storage tank (Gr-A-1 tank)			
Sampling date	April 16, 2013			
Analysis location	Fukushima Daiichi		Fukushima Daini	
Purpose of analysis	(1) Comparison with the guide maximum allowable value	(2) Detailed analysis	(1) Comparison with the guide maximum allowable value	(2) Detailed analysis
Cesium-134	ND (<0.42)	ND (<0.042)	ND (<0.13)	0.22
Cesium-137	ND (<0.59)	ND (<0.059)	0.31	0.39

*"ND" means that the value is below the detection limit. The figures in parentheses are the detection limit values.

3. Causes and the Measures that Will Be Taken against Them

<Causes>

- At the Fukushima Daiichi nuclear power station, measurement of samples with a low radioactivity concentration on the order of 0.01 Bq/L such as water samples from pumping wells for groundwater bypassing and temporary storage tanks using a Marinelli container has entailed the need to confirm the shielding effect on the BG of the samples. However, because most of the measurement that has been performed at the Fukushima Daiichi nuclear power station to date has been measurement of samples with high radioactivity concentrations, there has been a lack of consideration for measurement of samples with low radioactivity concentrations using Marinelli containers.

- The fact that it is necessary to confirm whether or not the shielding effect of the BG on measurement samples in BG measurement is negligible has not been mentioned in our in-house procedure manual, and no instruction in relation to that need has been given to the companies performing radioactivity concentration measurement on the premises of the Fukushima Daiichi nuclear power station for us.

<Measures that Will Be Taken>

- For measurement of samples with low radioactivity concentrations using a 2-liter Marinelli container at the Fukushima Daiichi nuclear power station, confirmation will be made as to whether or not the measurement device to be used is one that allows the shielding effect to be ignored in BG measurement, and the Ge semiconductor-based detector to use for the measurement will be selected.

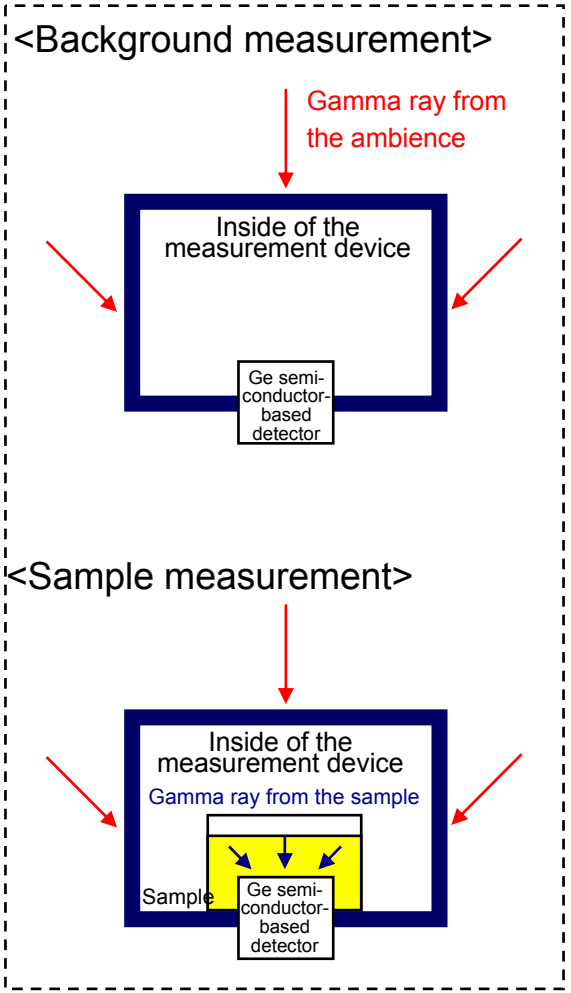
- Because the new analysis facility to be completed at the end of June 2013 near the entry and exit control facility will allow measurement in environments with low BG, that low BG-capable analysis facility will be used for measurement of samples with low radioactivity concentrations such as water samples from pumping wells for groundwater bypassing and temporary storage tanks.

- At the Fukushima Daiichi nuclear power station, the above-mentioned measures will be reflected in the in-house procedure manual and the employees who perform analysis work will be notified of the changes. In addition, the measures will be reflected in the Analysis Work Entrustment Specifications.

- With regard to the Fukushima Daini nuclear power station, presently there is no effect of sample shape on BG measurement. However, should BG levels change in the future, confirmation will be made as to whether the shielding effect of BG on measurement samples can be ignored.

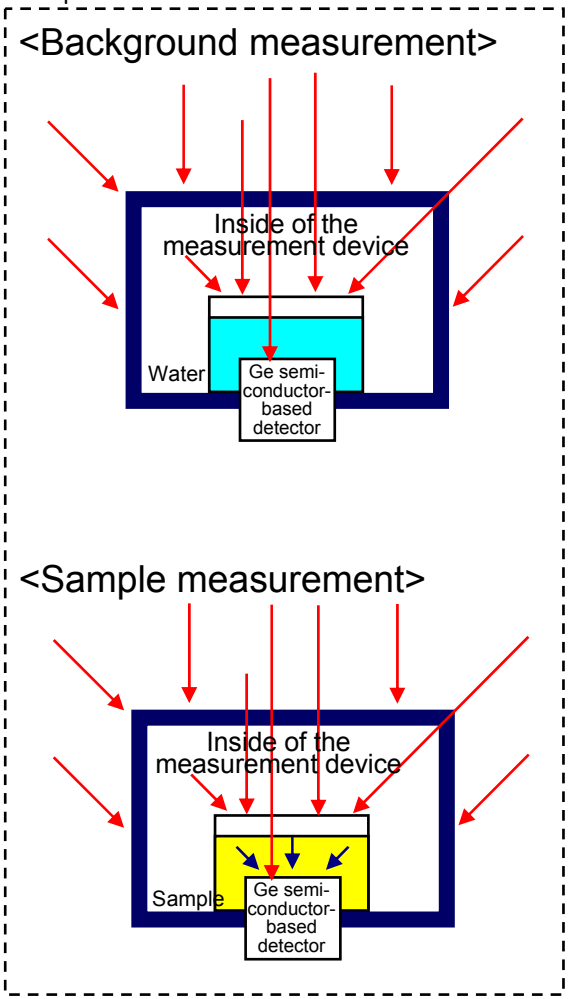
(Reference Information) Schematic Diagrams of a Radioactivity Measurement Technique Using a Germanium Semiconductor-based Detector

■Measurement in cases where the background level is normal



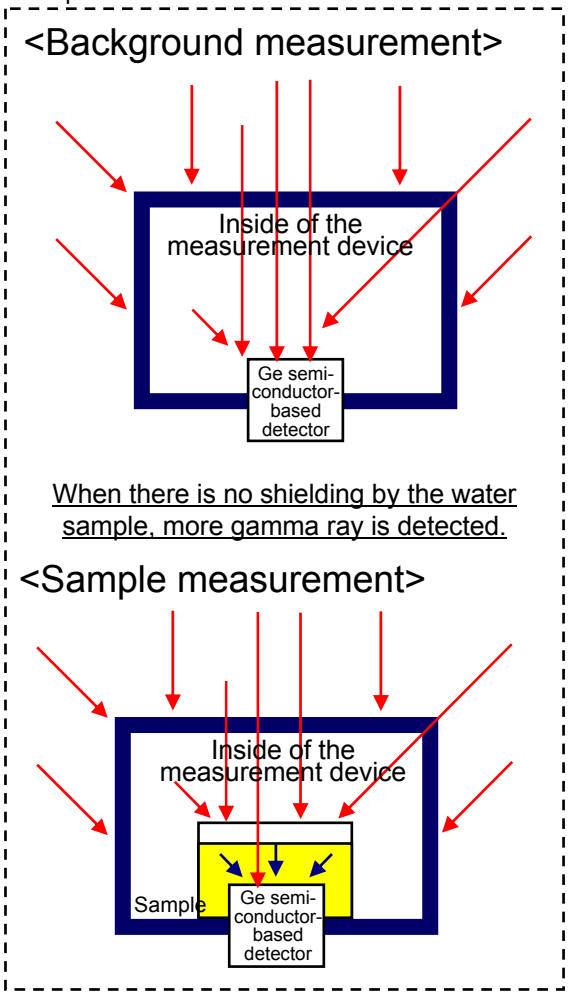
The net radioactivity concentration in the sample is calculated by subtracting the measured background radioactivity concentration from the measured radioactivity concentration in the sample.

■Measurement in cases where the background level is high and the shielding by the measurement sample is taken into account.



Gamma ray from the ambience is detected even in the measurement device. The background is measured with an uncontaminated water sample placed in the device so that the effect of the shielding by the measurement sample can be taken into account.

■Measurement in cases where the background level is high and the shielding by the measurement sample is **not** taken into account.



When there is no shielding by the water sample, more gamma ray is detected.

Measuring the background without placing a water sample in the device gives a higher measured background radioactivity concentration. This higher measured background radioactivity concentration affects the net radioactivity concentration in the sample that is obtained by the subtraction.