Regarding the steps to be taken regarding the leakage of water containing radioactive materials at the water desalination of Fukushima Daiichi Nuclear Power Station

December 8, 2011

Tokyo Electric Power Company

This report contains the current result of the items ordered by the documents “Steps to be taken regarding the leakage of water containing radioactive materials at the water desalination of Fukushima Daiichi Nuclear Power Station (order)”

【Contents of the order】

Regarding the fact that water including radioactive material has leaked outside of the building, we require you to act as written below and report to NISA every completed step without delay.

1. Investigate the cause of this incident and establish plans to prevent future similar incidents.
2. Since there was leakage also from the barrage that was supposed to prevent leakage expanding further from the evaporative concentration apparatus, immediately confirm the soundness of other barrages and reinforce them if necessary, and establish future plans to prevent leakage from the barrage, such as strengthening patrols or installing leakage detectors.
3. Confirm the range and amount of the leakage, including whether or not there was any to the ocean, and evaluate the impact of the radioactive materials to the surroundings.

１．Cause of the leakage and countermeasures to prevent the reoccurrence

（１）Summary of the incident

At around 11:33 am on December 4, a site worker has confirmed there is accumulated water within the barrier of housing for 3A to 3C evaporative concentration apparatus.

At around 11:52 am, 3A evaporative concentration apparatus was out serviced and at around 12:14 pm a worker has confirmed by sight leakage was stopped.

Due to the investigation, at around 2:30 pm, a crack was found in the concrete bottom of the housing and confirmed water was leaking from the crack to the gutter outside of the housing.

And as spread of leaked water from housing was found between the barrier and the concrete bottom, sandbag was started to set around the leaking crack from 3:00 and to the gutter from 3:10 pm and completed at 3:30 pm and confirmed there was no leakage of water from the area where sandbag was placed.

From 6:10 pm to 10:20 pm, accumulated leaked water was transferred to the waste liquid RO supply tank.

On December 5, inspection of the 3A to 3C housing of evaporative concentration apparatus was conducted, due to the observation of the dripped mark of the leaked water, it is estimated the leakage was from the flange of the connected pipe of the waste liquid heater (a heat exchanger).

After the identification of leaked point by using purified water confirmation, a detailed investigation of the leaked point such as teardown analysis will be implemented to determine the cause and to establish countermeasure to prevent reoccurrence.

*The cause and countermeasures to prevent reoccurrence will be reported as soon as it is summarized.

As the gutter is connected to the general water drainage channel, sampling of sea water of south discharge channel where exit of the drainage channel was conducted and as a result of the nuclide analysis, it was in the same level or slightly higher than recent result of daily announced radioactive level. On December 5, sampling of sea water of south discharge channel where exit of the drainage channel was conducted successively, the result was in the same level or slightly higher than recent result of daily announced radioactive level.

（２）Leaked point

① Leaked point of 3A of evaporative concentration apparatus

On December 5, leaked water in the housing was discharged and as a result of site inspection, as the leakage mark was confirmed at the flange of outflow side of waste liquid heater (a heat exchanger) RO condensed water (original treated water of evaporative concentration apparatus) supply pipe in the upstream side of VVCC evaporator of 3A evaporative concentration apparatus, it is estimated highly likely the leakage was from the relevant point. As the current atmosphere radiation level is very high, after taking necessary countermeasures to reduce radioactive exposure such as decontamination, identification of leaked point by making up purified water to 3A evaporative concentration apparatus will be implemented.

②Leaked point of housing of 3A to 3C evaporative concentration apparatus

On December 5, leaked water in the housing was discharged and as a result of site inspection, wide spreading gap was confirmed due to the deformation of the sealing substance in the part of joint of the concrete bottom which was built segmental.

Judging from the leaked part to the outside of the housing, it is estimated most of the outflow was flown out through this point.

In the part of the gap between the joint of concrete bottom and barrier, damage was found due to the deterioration of the seal substance, and it is estimated a part of the leaked water was also flown out from this point.

(Appendix 1: time sequential, Appendix 2: system diagram of water desalination facility, Appendix 3: system diagram of evaporative concentration apparatus, Appendix 4: schematic drawing of leaked point, Appendix 5: situation sketch of leakage)

（３） Cause of the leakage

①Cause of the leakage for 3A of evaporative concentration apparatus

On December 5, leaked water in the housing was discharged and as a result of site inspection, as the leakage mark was confirmed at the flange of outflow side of waste liquid heater (a heat exchanger) RO condensed water (original treated water of evaporative concentration apparatus) supply pipe in the upstream side of VVCC evaporator of 3A evaporative concentration apparatus, it is estimated highly likely the leakage was from the relevant point. As soon as the preparation is ready, identification of leaked point by making up purified water to 3A evaporative concentration apparatus will be implemented and targeting completing by the middle of December, detailed investigation of leaked part to determine cause of the leakage will be implemented.

②Cause of the leakage for housing of 3A to 3C evaporative concentration apparatus

On December 5, leaked water in the housing was discharged and as a result of site inspection, wide spreading gap was confirmed due to the deformation of the sealing substance in the part of joint of the concrete bottom which was built segmental. Judging from the leaked part to the outside of the housing, as most of the outflow was flown out through this point, it is estimated the main cause was the wide spread gap of the joint of the concrete bottom.

In the part of the gap between the joint of concrete bottom and barrier, damage was found due to the deterioration of the seal substance, and it is estimated a part of the leaked water was also flown out from this point.

③Status of investigation for similar housings

For the similar housings to 3A to 3C evaporative concentration apparatus, such as desalination facility (RO membrane), RO – 1A/B, RO2, RO3 and desalination facility (evaporative concentration) 1A to 1C, 2A, B inside house, was investigated and, similar to the case of housing of 3A to 3C evaporative concentrating apparatus, other than the damage found due to the deterioration of the seal substance, crack was found in the concrete bottom.

It is not considered to be resulted in immediate outflow of out side of the housings, however, repair work will be implemented for making sureness.

From the result of above, it is estimated the cause of the leakage for the housing of 3A to 3C evaporative concentration apparatus was due to the deterioration of the seal substance for the gap between the joint of concrete bottom and barrier.

It is considerable that lack of regular inspection of the status of the housing is one of the causes of the leakage.

（４） Countermeasures for prevent reoccurrence

①Countermeasures for preventing the leakage for 3A of evaporative concentration apparatus

After the inspection to determine the cause of the leakage which will be implemented by the middle of December, the countermeasure for prevent reoccurrence will be examined and it will be implemented and applied horizontally by January next year.

3A to 3C evaporative concentration apparatus will be out serviced until the completion of countermeasure to prevent reoccurrence will be taken.

②Countermeasures for preventing the leakage for housing of 3A to 3C evaporative concentration apparatus

a. Implement total inspection of the deterioration of sealing substance between steel barrier and concrete bottom and complete repair work by December 15.
b. The damage and gap caused between joint of the concrete bottom will be repaired by using epoxy painting by December 15.
c. As it is considerable that lack of regular inspection of the status of the housing is one of the causes of the leakage, monthly patrol of housing will be implemented and inspect deterioration of sealing substance and surface of the concrete bottom so that necessary repair will be taken.
d. Consider planned implementation of leakage prevention functional painting to all the surface of concrete bottom.

2．Confirmation of soundness of barrier and plan of countermeasures to prevent leakage

（1）Confirmation of soundness of barrier

a. Confirmation of soundness of barrier of the housing for the equipment to be installed outside

For the similar housings to 3A to 3C evaporative concentration apparatus, such as desalination facility (RO membrane), RO – 1A/B, RO2, RO3 and desalination facility (evaporative concentration) 1A to 1C, 2A, B inside house, damage was found due to the deterioration of the part of the seal substance on December 5, necessary repair work was taken on the same day.

(Appendix 6, soundness evaluation result of the barrier)

Crack was also found in the concrete bottom, though it is not considered to be resulted in immediate outflow of out side of the housings, repair work was implemented for making sureness by injecting epoxy painting and completed by December 6.

Monthly patrol of housing will be implemented and inspect deterioration of sealing substance and surface of the concrete bottom so that necessary repair will be taken.

Planned implementation of leakage prevention functional painting to all the surface of concrete bottom will be considered.

b. Confirmation of soundness of barrier of existing housings

Accumulated water treatment facilities (oil separation facility, decontamination facility, Cesium adsorption facility, Second cesium adsorption facility) were installed within the barrier of existing housings (Process main building, incineration workshop building, High temperature incinerator building), as the barrier of the existing housings was designed and build to put painting on no gap concrete made, hence there is no risk of leakage like in the case of short term built barrier of housing.

Leakage prevention pan and leakage detector was installed to the tanks and in the area of accumulated water treatment was installed where high radiation was observed, ITV was installed so that checking of the leakage was possible, and further, even if the leakage was occurred, as it will flow down to the accumulated water containment area in the underground of the building through the bottom drain funnel in the area where accumulated water treatment facility was installed, there will be no leakage to the outside of the building.

However, for the purpose of making sureness, reinvestigation will be implemented for the Cesium adsorption facility and Second cesium adsorption facility targeting such investigation to be completed by December 9.

For the oil separation facility and the decontamination facility, as the radiation is very high in the installed area, from the view point of decreasing the exposure for radiation, investigation will be implemented taking the opportunity if there is a necessity to go into the area.

（2） Plan of countermeasures to prevent leakage

a. Countermeasure to prevent expansion of leakage of housing for the equipment to be installed outside

For further plan of countermeasure to prevent leakage for the housing of desalination facility (RO membrane), RO – 1A/B, RO2, RO3 and desalination facility (evaporative concentration) 1A to 1C, 2A, B, leakage detector will be installed within the barrier to prevent expansion of the leakage by December 15, and install alarm function will be additionally installed in the control room if in the event leakage is occurred.

Until the installment of leakage detector will be completed, monitoring will be enhanced by increasing frequency of the patrol from current once a day to six times a day (however, in the high radiation area, it will be once a day).

From the view point of decreasing the exposure for radiation, installment of remote monitoring camera will be examined.

Planned implementation of leakage prevention functional painting to all the surface of concrete bottom will be considered.

b. Countermeasure to prevent expansion of leakage for existing housings

Accumulated water treatment facilities (oil separation facility, decontamination facility, Cesium adsorption facility, Second cesium adsorption facility) were installed within the barrier of existing housings (Process main building, incineration workshop building, High temperature incinerator building), as the barrier of the existing housings was designed and build to put painting on no gap concrete made, hence there is no risk of leakage like in the case of short term built barrier of housing.

However, for the purpose of making sureness, monthly building patrol will be conducted to inspect the surface painting of the barrier and implement necessary repair will be taken.

For the oil separation facility and the decontamination facility, as the radiation is very high in the installed area, from the view point of decreasing the exposure for radiation, investigation will be implemented taking the opportunity if there is a necessity to go into the area.

３． Assessment of impact of the radioactive materials to the surrounding environment

As it will take nearly one month to obtain result of the analysis of Strontium in the leaked water, provisional estimate was conducted by using most recent result of analysis of inlet water of evaporating concentration facility which was considered equivalent to the leaked water. Definitive estimation will be conducted when the analysis of Strontium will be confirmed and will be reported accordingly.

（１） Duration

At 11:33 am on December 4, when a patrolman checked the accumulated water in the evaporative concentration apparatus housing, there was no leaked water at the road outside of the building. As such, we determined that the leak occurred after 11:33 am. At around 2:30 pm, we found leak to the road from the crack in the concrete barrier of the housing. At 3:30 pm, we stopped the leakage by applying sandbags to the leaking part from the outside of the housing. The duration of leakage is evaluated as approx 4 hours at maximum, from 11:33 am to 3:30 pm.

（2）Leakage rate

The leakage rate is evaluated at approx 1 liter / min by visual inspection of the flow rate at the crack in the concrete barrier at 2:30 pm.

(reference: approx 0.6-0.8 liter / min by Bernoulli equation)

（3）Leaked volume from the housing

From the above (1) and (2), the evaluated leaked volume from the housing to the outside is 240 liter.

(1 liter / min times 240 minutes is 240 liters)

（4）Leaked volume to the general drainage (appendix 7: evaluation of the leaked volume to the general drainage)

ａ．The time from the crack to the gutter

The leaked water from the housing spread from the crack in the concrete floor to the road and flowed to the gutter at the east side of the housing. From the left out wetted surface on the road, the size was estimated as a right triangle with 15m base and 10m height (75 m^2), depth 1 mm. As this corresponds to 75 liters of leaked volume, taking account of the leak rate, 1 liter / min evaluated in (2) above, the time to the gutter is estimated as approx 75 min (11:30 am – 12:45 pm).

ｂ．Duration of leakage to the gutter (U shaped gutter)

Around 3:10 pm, we completed applying sandbags to the crack. As such, the duration of leakage to the gutter is estimated as approx 145 minutes (12:45 pm – 3:10 pm) being from the time when the leaked water reached the gutter (12:45 pm) to completion of applying sandbags (3:10 pm).

ｃ．Duration of leakage after applying sandbags

At 3:10 pm, we confirmed that leakage from the crack in the concrete floor did not seep out of sandbags. At 3:30 pm, we completed applying sandbags. Between this 20 minutes period (3:10 pm – 3:30 pm), although leakage from the crack continued, there was no leakage to the general drainage.

ｄ．The volume of leakage to the general drainage

From a to c above (total volume of leakage 240 liters – pooled water 75 liters – accumulated water within sandbags 20 liters), the volume of leaked water from the housing is evaluated as 145 liters. To be conservative, we use 150 liters as the volume of leakage to the general drainage for evaluation.

After stop of leakage from the housing, there was accumulated water in the housing. We transferred this to a temporary tank. The total volume was approx 14 m^3.

（５）The volume of leaked radioactive substances (tentative figures)

As for radioactive substances contained in the leaked water, we evaluated the density of (i) Cesium that largely affects to dose evaluation and (ii) Strontium that has high density in the treated water as below.

As for Strontium, as it takes approx one month to have the evaluation result of Beta nuclides, we decided to estimate from the measurement data of water at the entrance of evaporative concentration apparatus at the closest time. We measured the ratio of Beta nuclides from Strontium in the total Beta nuclides of water. We then multiplied this ratio to the total Beta nuclides of leaked water from the evaporative concentration apparatus and calculated the density of Strontium 89 and 90.

As for Cesium 134 and 137, we used data of leaked water from the evaporative concentration apparatus sampled on December 4.

(Appendix 8: sampling results)

Density and leaked volume of radioactive substances (tentative figures)
Strontium 89: 7.4 x 10^4 Bq/cm^3 (1.1 x 10^{10} Bq)
Strontium 90: 1.0 x 10^5Bq/cm^3 (1.5x 10^{10} Bq)
Cesium 134: 1.6 x 10^1 Bq/cm^3 (2.4 x 10^6 Bq)
Cesium 137: 2.9 x 10^1 Bq/cm^3 (4.4 x 10^6 Bq)

The aggregate of the above four nuclides is 2.6 x 10^{10} Bq. In this, the aggregate of Strontium, Beta nuclides is 2.6 x 10^{10} Bq and that of Cesium, Gamma nuclides is 6.8 x 10^6 Bq.

<data used for evaluation>

	Entrance of the evaporation condensation apparatus (September 20)	Leaked water from the evaporation condensation apparatus (December 4)
Total Beta	3.9 x 10^5 Bq/cm^3	5.4 x 10^5 Bq/cm^3
Strontium 89	5.4 x 10^4 Bq/cm^3	-
Strontium 90	7.6 x 10^4 Bq/cm^3	-

<reference> past released volume

（a）Leakage of contaminated water from Unit 2

Volume	520m^3 (from April 1 to April 6)
I-131	2.8×10^{15} Bq
Cs-134	9.4×10^{14} Bq
Cs-137	9.4×10^{14} Bq
Total	4.7×10^{15} Bq

（b）Release of contaminated water in the Centralized Radiation Waste Treatment Facility and sub-drain water of Units 5 and 6

Volume	10,393m^3 (From April 4 to April 10)
I-131	6.6×10^{10} Bq
Cs-134	4.2×10^{10} Bq
Cs-137	4.2×10^{10} Bq
Total	1.5×10^{11}Bq

（c）Leakage of contaminated water, Unit 3

Volume	250m^3 (From May 10 to May 11)
I-131	8.5×10^{11} Bq
Cs-134	9.3×10^{12} Bq
Cs-137	9.8×10^{12} Bq
Total	2.0×10^{13} Bq

（6）Evaluation of the annual effective dose (tentative figures)

In order to evaluate the environmental impact by the leaked water, we evaluated the annual effective dose from intake of marine products with the existence of leaked radioactive substances.

We calculated the annual average concentration of radioactive substances at the sea area with marine products, taking account of the dilution by seawater where leaked water spread and convert to annual average from the duration of leakage. By applying formulas and coefficients from "Guidelines for the target dose rate around Light Water Nuclear Power Reactor Facilities" (NSC), we calculated the annual effective dose (internal dose) by the average density of radioactive substances. Target nuclides are four, Strontium 89 and 90 with relatively high density after absorption of Cesium and Cesium 134 and 137, Gamma nuclides with high impact on the dose evaluation.

The evaluation result is as below:

Strontium 89:	1.7×10^{-4} mSv/year
Strontium 90:	3.5×10^{-3} mSv/year
Cesium 134:	3.8×10^{-6} mSv/year
Cesium 137:	4.7×10^{-6} mSv/year
Total (four nuclides):	3.7×10^{-3} mSv/year

(appendix 9: the annual effective dose by intake of marine products (tentative evaluation))

We will analyze Strontium in the leaked water and seawater around the Power Station. Together with Gamma nuclides analysis result, from actual measurement data, we will conduct the final evaluation of the released volume and the effective dose. Also, we will evaluate the environmental impact in conjunction with the periodic marine monitoring.

4. Appendix

Appendix 1: time sequential

Appendix 2: system diagram of water desalination facility

Appendix 3: system diagram of evaporative concentration apparatus

Appendix 4: schematic diagram of leaked point

Appendix 5: situation sketch of leakage

Appendix 6: soundness evaluation result of the barrier

Appendix 7: evaluation of leaked volume to the general drainage

Appendix 8: sampling results

Appendix 9: the annual effective dose by intake of marine products (tentative evaluation)

Appendix 1

[December 3]

・ At 2:34 pm, started the evaporative concentration apparatus 3A

[December 4]

・ At 11:33 am, a subcontractor ' s worker found accumulated water during patrol.
・ At 11:52 am, stopped the evaporative concentration apparatus 3A.
・ At 12:14 pm, confirmed that the leakage of water stopped.
・ At 2:30 pm, confirmed that there was a crack on the concrete floor in the housing for evaporative concentration apparatus. From there, part of water leaked to outside and part of it flew into the gutter.
・ At 3:00 pm, began applying sandbags to the leaked point from the housing.
・ At 3:10 pm, completed applying sandbags to the leaked point from the housing. Began applying sandbags to the gutter.
・ At 3:30 pm, completed stopping water by sandbags.
・ From 6:10 pm to 10:20 pm, transferred accumulated water in the barrier by a submerged pump etc to wastewater RO supply tank.

[December 5]

・PM, confirmed the location of leakage with the evaporative concentration apparatus stopped.
・From AM to PM, confirmed the soundness of the barrier.

[December 6]

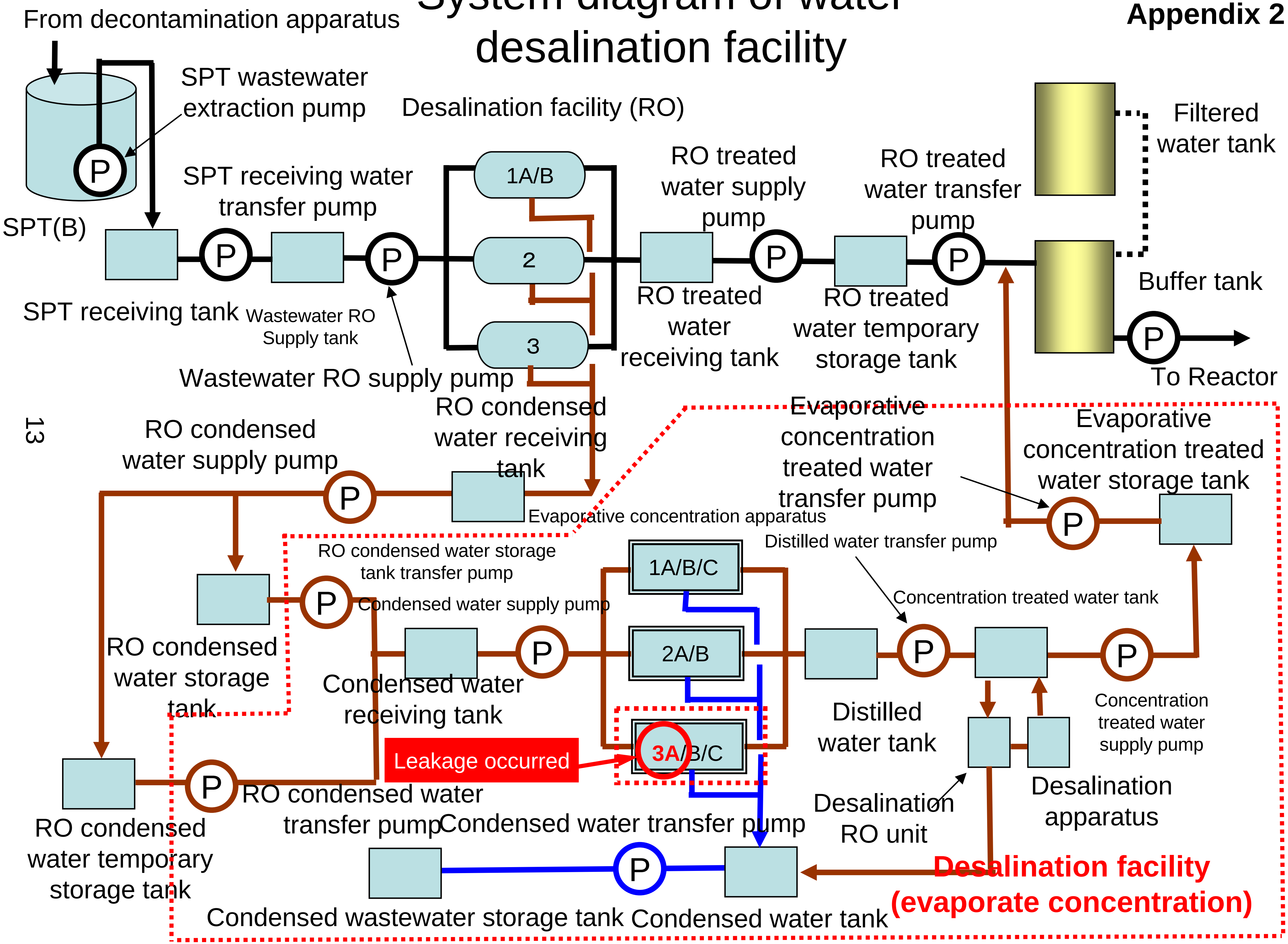
・ AM, confirmed the investigation direction of the cause of leakage by TEPCO and the apparatus erection contractor.
・ PM, prepared for operation of the evaporative concentration apparatus (using filtered water)

[future plan]

・ Confirm the location of leakage with the evaporative concentration apparatus in operation (using filtered water). Investigate the cause of leakage.
・ Plan the preventive countermeasure and application to similar apparatus.
・ Implement the preventive countermeasure and application to similar apparatus.

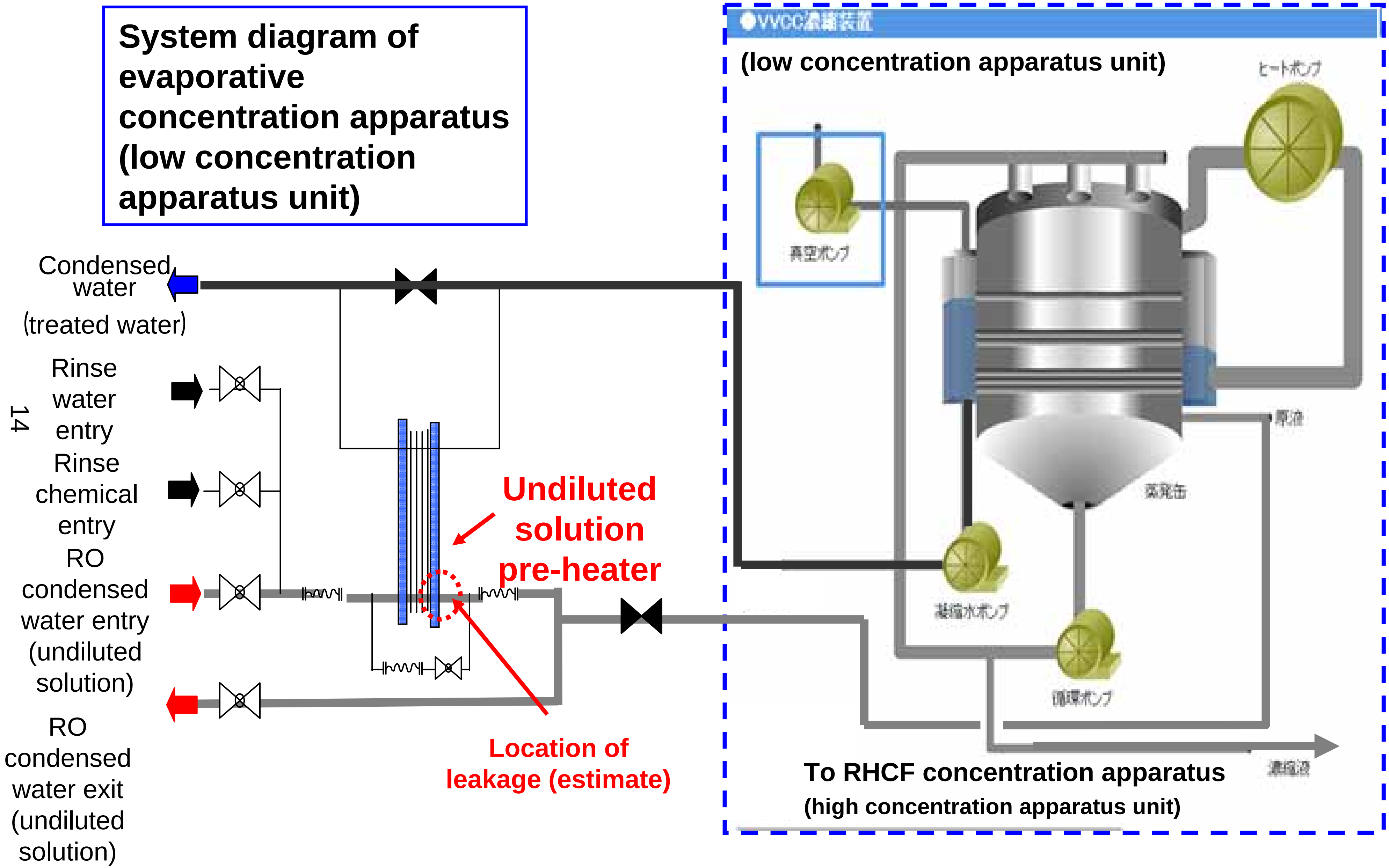
System diagram of water desalination facility

Appendix 2



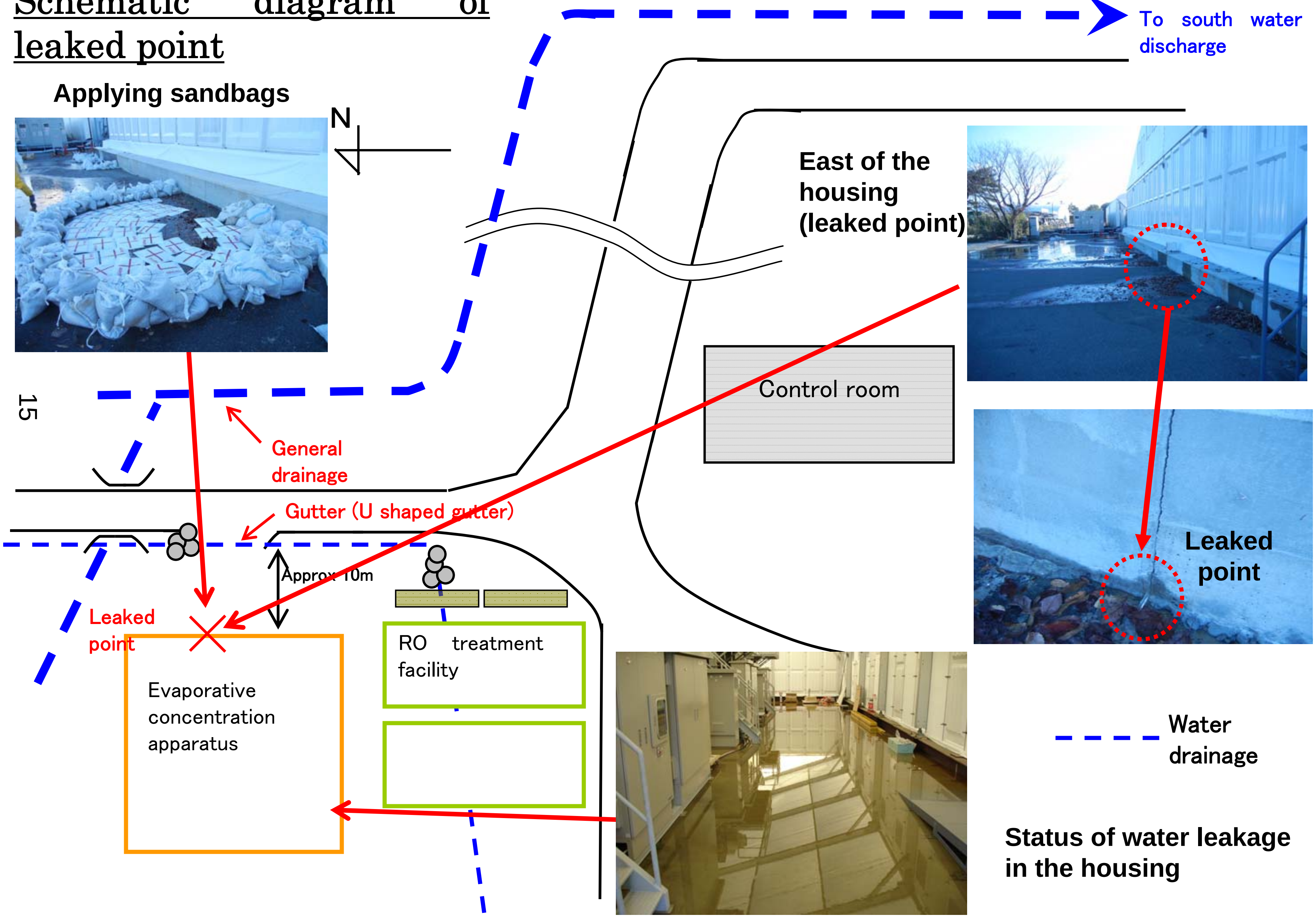
Appendix 3

System diagram of evaporative concentration apparatus (low concentration apparatus unit)

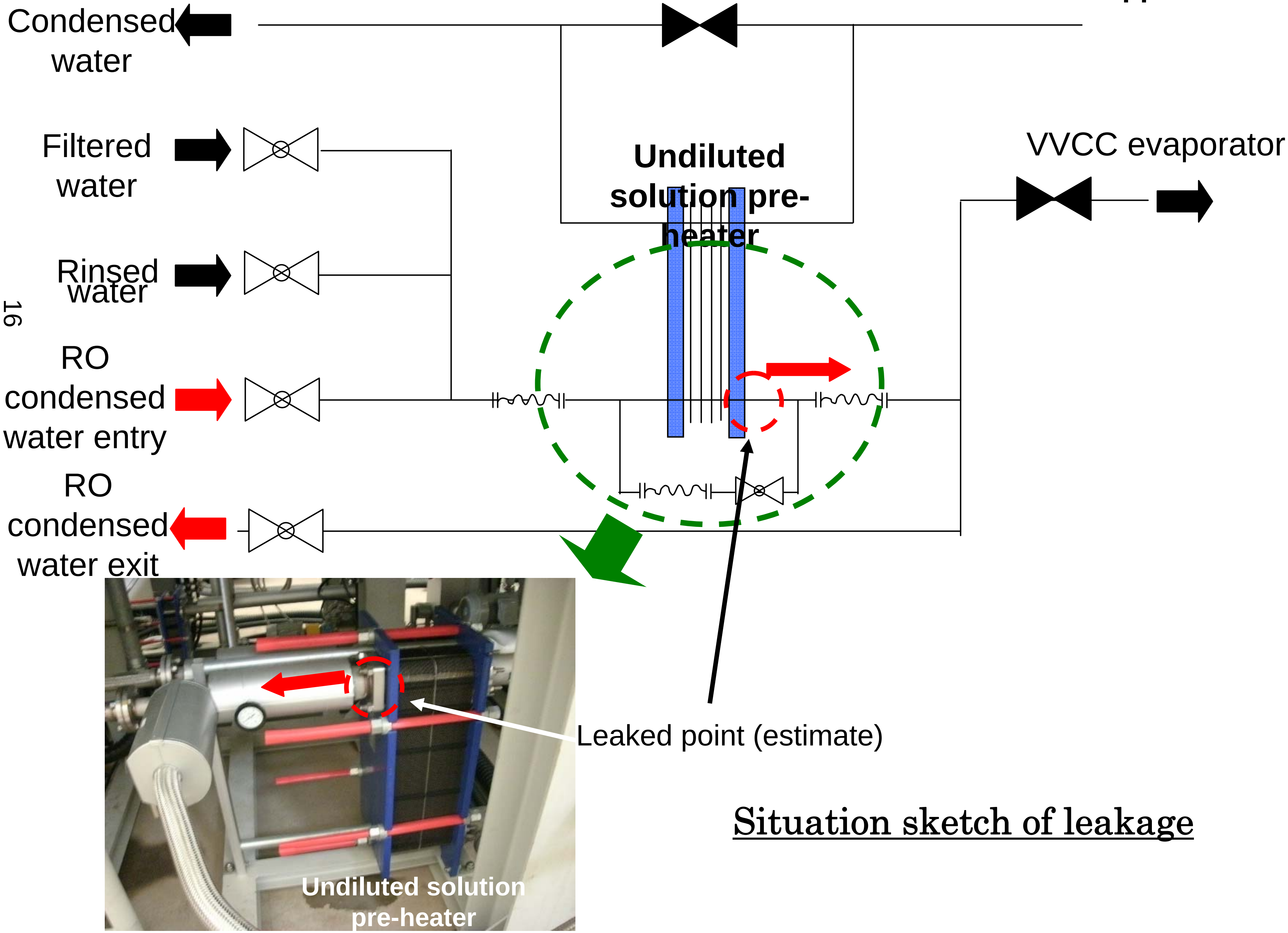


Appendix 4

Schematic diagram of leaked point



Appendix 5



<u>Situation sketch of leakage</u>

Applying caulking

Appendix 6

■Check soundness of other barriers (December 5)

- Maintain caulking
- Confirm tiny cracks on the floor (recent repair by epoxy painting)

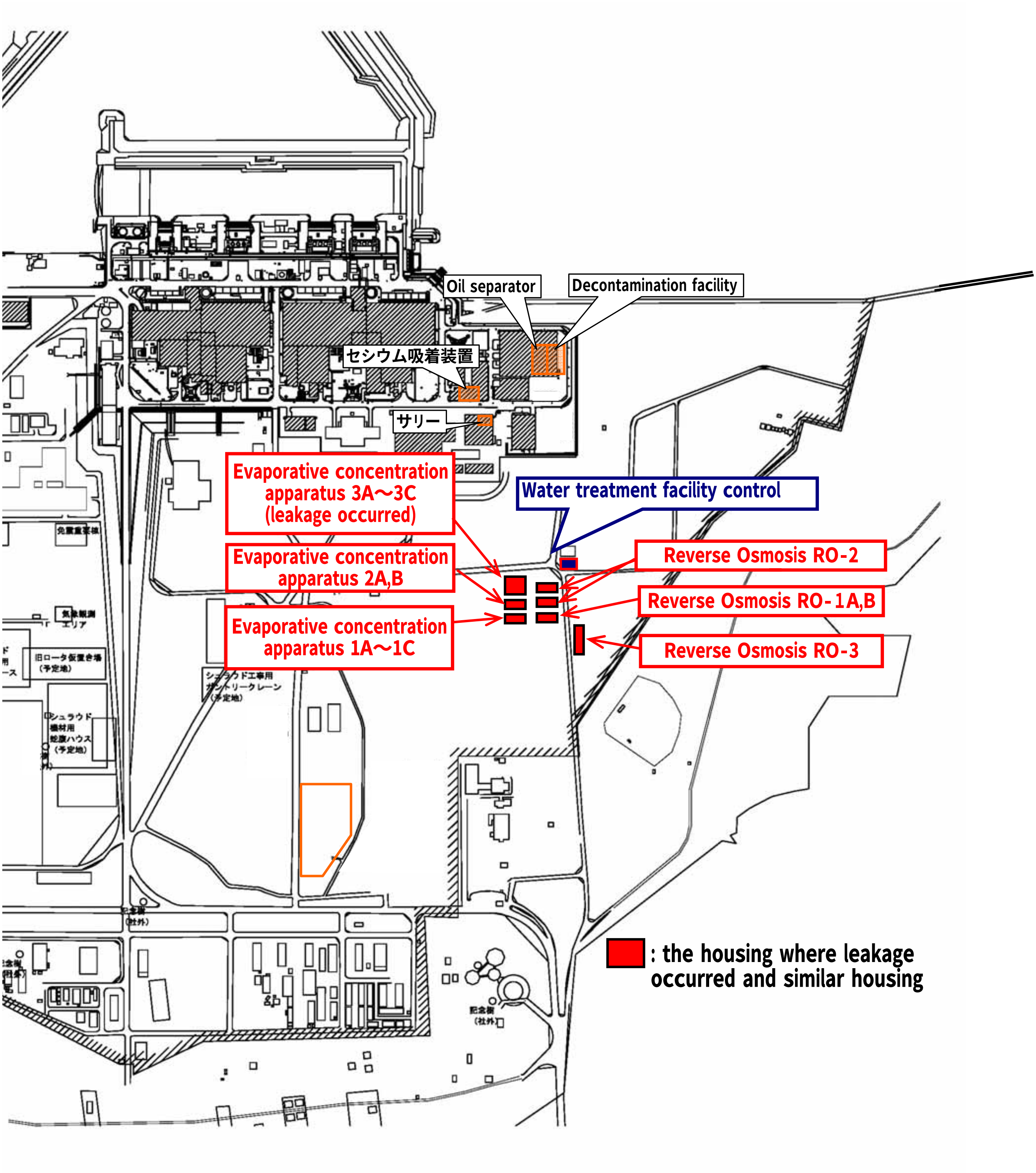

RO3 bellows housing


Evaporative concentration apparatus 2 bellows housing

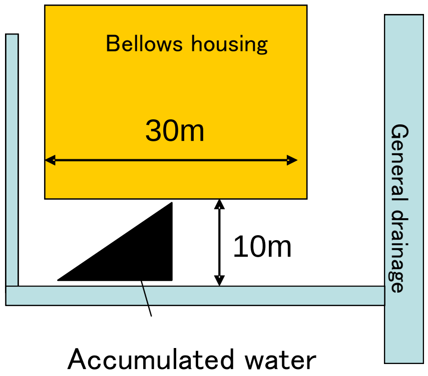

RO2 bellows housing


RO3 bellows housing (to be repaired)

Schematic location diagram of the housing where leakage occurred and similar housing

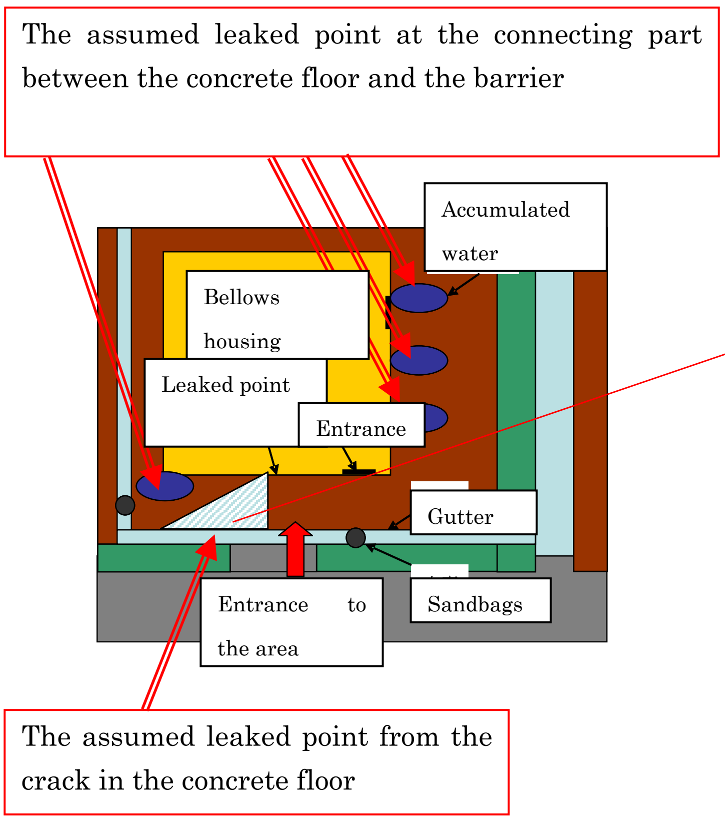


Evaluation of leaked volume to the general drainage

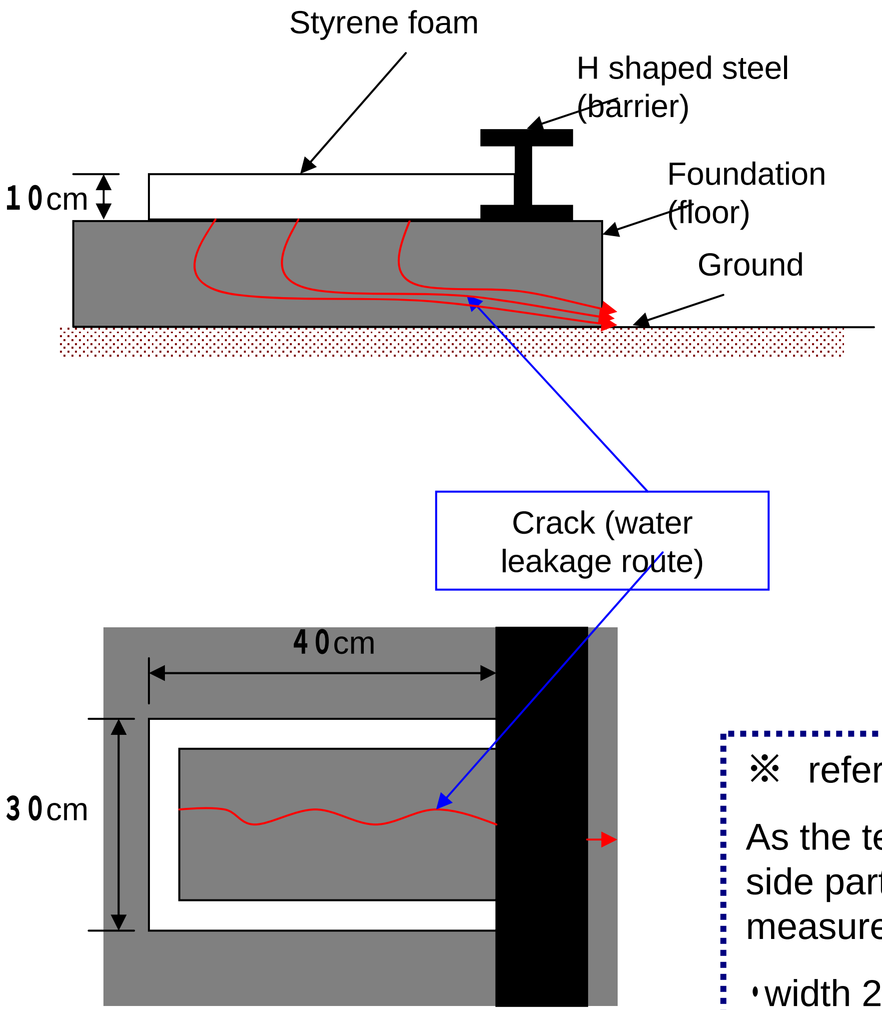


■Leakage velocity
①Visual observation: approx 1 L/min (approx 180 ml in 10 sec)
②Bernoulli equation: approx 0.8 L/min (slit width 1 x height 40mm)
③Test: approx 0.125 L/min (water depth 5cm, slit width 2 x height 20mm)
■Volume of water at the wetted surface of the road
15m x 10m x ½ x 1mm = 75L
■The volume of leakage to the general drainage
①From confirmation of leakage 11:30 am to applying sandbags 3:30 pm is approx 240 min.
②Formation of wetted surface took approx 75 min.
③Applying sandbags to U shaped gutter took approx 10 min.
④Applying sandbags around the crack took approx 10 min.
・Flowing into U shaped gutter to applying sandbags was the duration of leakage. This was 240−(75+10+10)=145 min.
・The total volume of leakage to the general drainage was assuming conservative leakage velocity of 1L/min, 1L/min x 145 min = 145L rounded up to [approx 150L]

	Velocity of leakage1L/min Depth of puddle 1mm		Note
	time	time lapse	
Reached from the crack to the U shaped gutter	11:30am-12:45pm	75	②triangle shape on the road (15×5m)
Continued leakage to the U shaped gutter	12:45pm-3:00pm	135	
Applied sandbags around the crack	3:00pm-3:10pm	10	Leakge almost stopped
Applied sandbags at the U shaped gutter	3:10pm-3:20pm	10	③Stopped leakage to the general drainage
Completed applying sandbags around the crack	3:20pm-3:30pm	10	④
		240	①



Leaked volume test result from the crack in the floor



[Content of the test]

We formed an enclosure (width 30cm, length 40cm, height 10cm) around the crack in the foundation (floor) of the bellows housing by styrene foam, poured 5cm of water and measured the leaked volume of water to the outside of the housing.

[Test result]

・Date and time: 2:30 pm – 3:30 pm on December 5, 2011

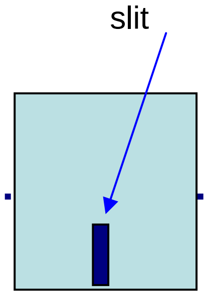
・The volume was a blur and could not be measured.

※ reference

As the test was not successful, we made a slit to the lower side part of a plastic container, poured 5cm of water and measured the water outflow.

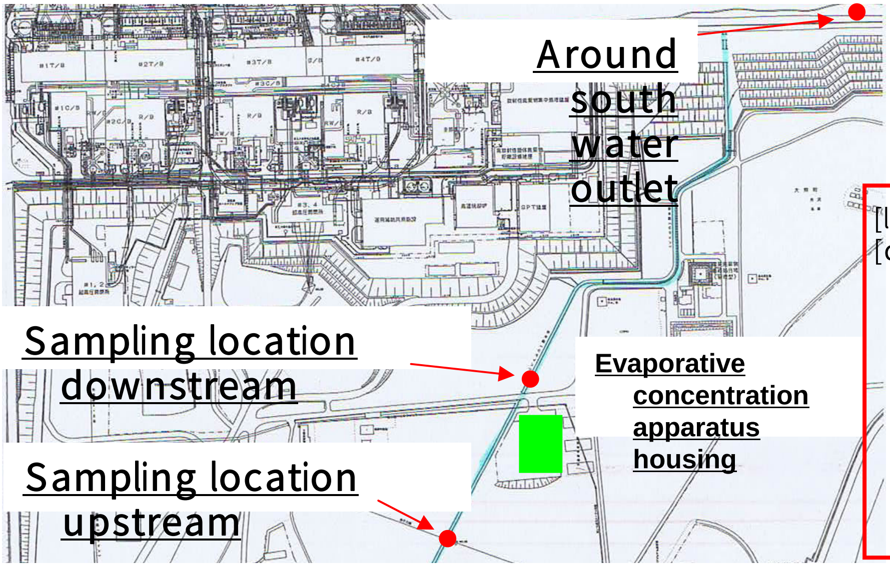
・width 2mm, height 20mm: 120cc/min

・width 3mm, height 30mm: 270cc/min



Sampling result of leaked water, evaporative concentration apparatus, Fukushima Daiichi NPS

Appendix 8



[location] around the south water outlet
[date and time] 5:05 pm on Dec 4, 2011 (Sun)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	8.9×10^{-4}
Cs-134	1.3×10^{-2}	1.4×10^{-3}
Cs-137	1.8×10^{-2}	1.2×10^{-3}
Total β	－	－

[date and time] 6:45 am on Dec 5, 2011 (Mon)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	検出限界未満	6.1×10^{-4}
Cs-134	5.2×10^{-3}	9.9×10^{-4}
Cs-137	5.7×10^{-3}	1.0×10^{-3}
Total β	5.3×10^{-1}	1.9×10^{-2}

[location] downstream of water discharge (evaporative concentration apparatus)
[date and time] 5:25 pm on Dec 4, 2011(Sun)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	2.5×10^{-2}
Cs-134	6.1×10^{-2}	4.0×10^{-2}
Cs-137	5.2×10^{-2}	3.7×10^{-2}
Total β	4.9×10^{5}	1.8×10^{3}

[date and time] 10:16 pm on Dec 4, 2011 (Sun)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	9.1×10^{-3}
Cs-134	ND	1.8×10^{-2}
Cs-137	ND	2.0×10^{-2}
Total β	－	－

[date and time] 6:25 am on Dec 5, 2011 (Mon)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	7.2×10^{-3}
Cs-134	ND	1.7×10^{-2}
Cs-137	ND	1.9×10^{-2}
Total β	4.9×10^{0}	3.6×10^{-2}

[location] upstream of water discharge
[date and time] 10:07 pm on Dec 4, 2011 (Sun)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	6.1×10^{-3}
Cs-134	ND	1.4×10^{-2}
Cs-137	ND	1.7×10^{-2}
Total β	1.5×10^{-1}	4.2×10^{-2}

[date and time] 6:18 am on Dec 5, 2011 (Mon)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	6.1×10^{-3}
Cs-134	ND	1.4×10^{-2}
Cs-137	ND	1.7×10^{-2}
Total β	－	－

[location] leaked water, evaporative concentration apparatus
[date and time] 1:15 pm on Dec 4, 2011 (Sun)

Nuclides	Density of Radioactive substances (Bq/cm³)	Lower detection limit (Bq/cm³)
I-131	ND	3.1×10^{0}
Cs-134	1.6×10^{1}	3.8×10^{0}
Cs-137	2.9×10^{1}	3.0×10^{0}
Total β	5.4×10^{5}	1.9×10^{3}

The annual effective dose by intake of marine products (tentative evaluation)

In order to evaluate the environmental impact by the leaked water from the evaporative condensation apparatus on December 5, we evaluated the annual effective dose from intake of marine products with the existence of leaked radioactive substances.

1. Assumption of the annual average density of radioactive substances

Assuming that the volume of leakage to the water drainage as 150L, from the leakage velocity of 1L/min, the duration of leakage was 2 hours 30 minutes. As the annual average of flow rate at the sea area around Fukushima Daiichi is assumed at 10cm/sec (from the environmental impact assessment report, Units 7 & 8, Fukushima Daiichi), the leaked water would reach 900m of distance within this duration. If the leaked water spread out with 10m width and 1m height and spread to 900m away, the leaked water of 150L will be diluted to 1/60,000 by 9,000m^3 of seawater.

If we were to make the density of diluted seawater to the annual average with the duration of leakage, 2 hours 30 minutes, the annual average concentration of radioactive substances will be as follows:

The annual average concentration of radioactive substances at the sea area with marine products = the density of leaked water x (1/60,000) x (2.5/365x24)

2. Evaluation of the annual effective dose by the average density of radioactive substances

Based on "Guidelines for the target dose rate around Light Water Nuclear Power Reactor Facilities", we calculated the annual effective dose (internal dose) by the average density of assumed major radioactive substances.

Formula

The annual effective dose from intake of marine products

$Hw=365\Sigma Kwi \cdot Awi$

Kwi: the effective dose rate of nuclide I, Ａwi: the intake rate of nuclide i

$Awi = Cwi\Sigma_k (CF)ik \cdot Wk \cdot fmk \cdot fki$

Cwi: the density of nuclide I in seawater, (CF)ik: the concentration factor of nuclide I to marine product k

Wk: intake volume of marine product k, fmk: market dilution factor of marine product k

fki: the damping ratio of nuclide I from harvesting to intake of marine product k

Marine product: fishes, invertebrates, seaweeds

Calculation result

Nuclides （half-life time）	Density of leaked wate（Bq/cm^3） (Sampled on Dec 4, 2011. Sr was	The annual effective dose (mSv/year)

	assumed from total β.)	(tentative figures)
Sr-89 (50 days)	7.4×10^{4}	1.7×10^{-4}
Sr-90 (29 years)	1.0×10^{5}	3.5×10^{-3}
Cs-134 (2years)	1.6×10^{1}	3.8×10^{-6}
Cs-137 (30years)	2.9×10^{1}	4.7×10^{-6}
Total	—	3.7×10^{-3}