< Reference >
November 26, 2011
Tokyo Electric Power Company

Fukushima Daiichi Nuclear Power Station Unit 1-3 Evaluation method of the present amount of radioactive material released from the Reactor Building

Details of the sampling conducted at present

Sampling conducted at present

Measurement of dust density within the power plant site	extract and measure dust in the air around the reactor building and west gate and other locations within the power plant site in order to seize the tendency in the site.
Measurement of dust density Above Reactor building	・Extract and measure dust above the reactor building, near the ventilation system of the reactor building cover and the gas controlling system of the Primary Containment Vessel in order to evaluate radioactive material from the reactor building.
Measurement of dust density above the ocean	・Extract and measure dust above the ocean, which will not be affected by refloating radioactive material, in order to compare the evaluation of the released amount.
Measurement of descending Material inside and outside the site	・Extract and measure descending material inside and outside the site in order to evaluate the decreasing tendency of the released amount.
Measurement of subdrain water	・Extract and measure subdrain water of the turbine building and centralized radiation waste treatment facility in order to seize the effect to the underground water around the building.
Measurement of sea water	・Extract and measure sea water around the power plant in order to seize the effect to the ocean.

Measuring methods of the released radioactive material and the tendency

In June and July we measured radioactive material density in the air within the site (near buildings or sites)

→ We implemented evaluation based on the results of the measurement near the west gate※

*'Evaluation of Exposure Dose based on the density of Detected radioactive materials'

(Distributed on 23 July 2011)

From September, in order to get more accurate evaluation results, we evaluated the released amount based on the sampling results nearer to the point that is actually releasing radioactive material.

→ Evaluation based on results of the measurement above the reactor building

Also conducted measurement above the ocean, which will not be affected by refloating radioactive material, in order to compare the evaluation of the released amount.

Evaluated the amount of released radioactive material at present from unit 1-3

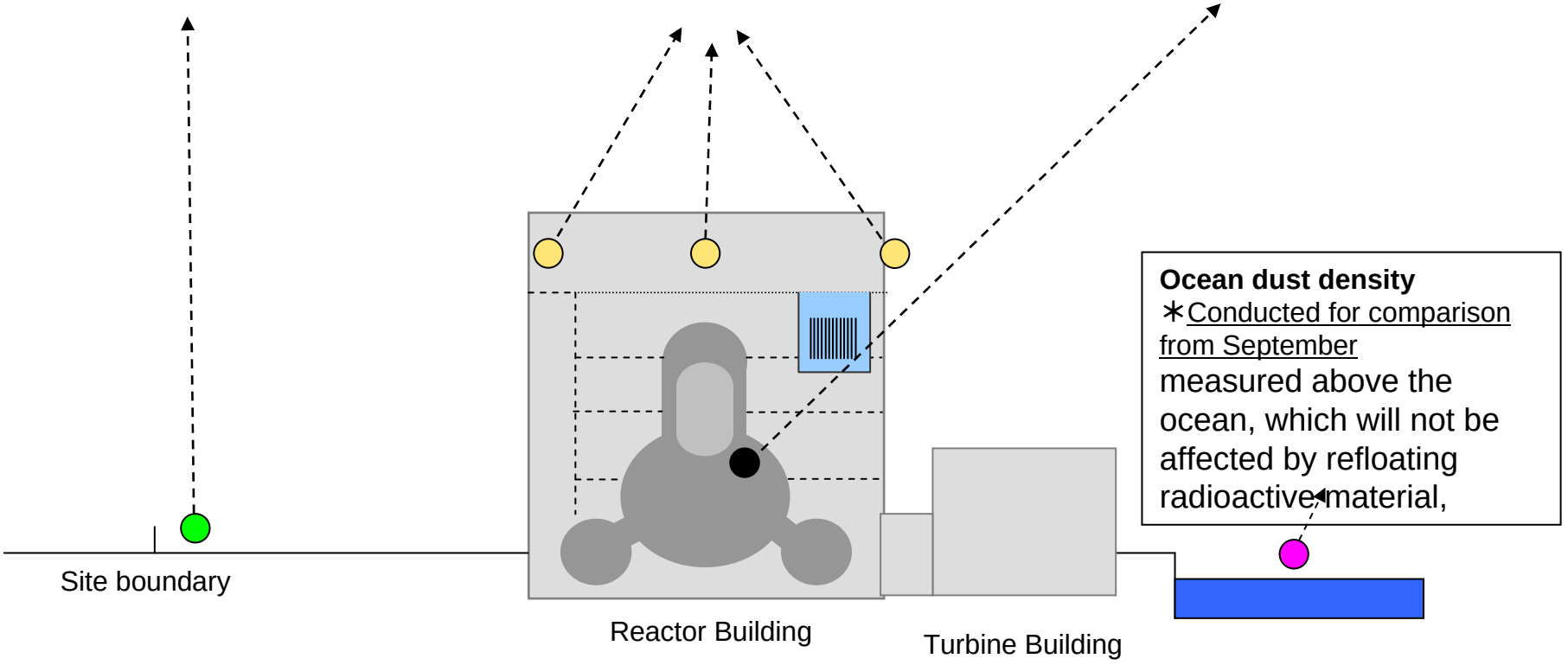
Implemented evaluation based on measurement results of November

Dust measuring points (overall image)

Dust density near west gate
Used for released amount evaluation in July and August

Dust density above reactor building
Used from September

Gas density inside the Primary Containment Vessel
Used for evaluating the released amount of noble gas as of November



*Dust density： Radioactive material density in the air

Method of Evaluation　Unit 1（1）

The evaluation will be made by adding the discharge amount from the upper side of the reactor building to the that from the inside of the reactor building through the equipment hatch. The effect of the exhaust system in the newly installed reactor building cover will be taken into consideration.

The radioactive dust concentration in air at the upper side of the reactor building (Cs-134+Cs-137) × assumed steam generation = the discharge amount from the upper side of the reactor building… ①

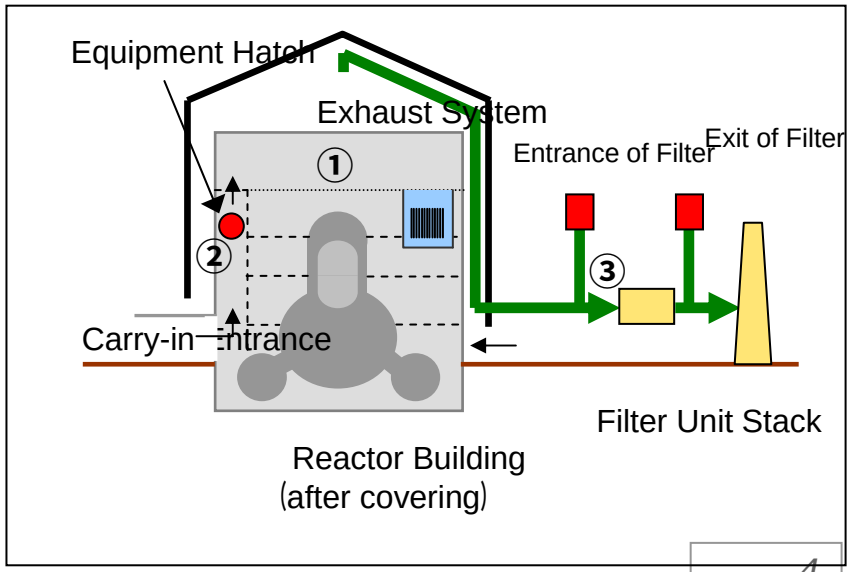
The dust concentration at the upper side of the equipment hatch (Cs-134+Cs-137) × air flow rate = the discharge amount from the inside of the reactor building … ②

The amount eliminated by the exhaust system in the reactor building cover…③

The discharge amount from the Unit 1 reactor building=①＋②－③

Measurement at the upper side of the reactor building

Measurement in the equipment hatch



Method of Evaluation　Unit 1（2）

①The upper side of the reactor
The figures in the previous evaluation (Oct. 17) will be used since the cover was installed and thus the dust concentration cannot be measured. 2 million Bq／h

②The inside of the equipment hatch（measured on November 4）
The dust concentration on the refueling floor is approx. ½ of the dust concentration in the equipment hatch according to the past record. dust concentration on the refueling floor (Bq/cm^3) =
The dust concentration in the equipment hatch (Bq/cm^3) X 0.5 = (1.4E-4+2.0E-4)×0.5=1.7E-4 Bq/cm^3
The discharge amount (Bq/s) = The dust concentration on the refueling floor (Bq/cm^3) X The air flow rate in the equipment hatch (m^3/s)×1E6(cm^3/m^3) = 1.7E-4×10.1×1E6 = 1.7E3 Bq/s = approx. 6 million Bq/h ～ 1.7E-4×12.5×1E6 = 2.1E3 Bq/s = approx. 8 million Bq/h

③The eliminated amount by the cover exhaust system (measured on November 4)
The discharge amount is the dust concentration at the entrance of the filter multiplied by the air flow rate.
The eliminated amount by the exhaust system = the dust concentration at the entrance of the filter (Bq/cm^3) × the air flow rate (m^3/s) × 1E6(cm^3/m^3) = (2.5E-5+3.2E-5)×12.4×1E6 = 7.1E2 Bq/s = Approx. approx. 3 million Bq/h

The evaluation: ①＋②－③
The discharge amount (million Bq/h) = 2 + (6～8） - 3= **Approx. 5～7 million Bq/h　（→0.1）**

(Reference) nuclide analysis results of radioactive materials in the air at the upper side of the Unit 1 R/B

Place of Sampling	Upper Side of Unit 1 Reactor Building① (around the 4th floor of the opening of the equipment hatch)		Upper Side of Unit 1 Reactor Building② (carry-in entrance in the reactor building)				②Density limit by the announcement of Reactor Regulation (Bq/cm3) (Density limit in the air to which radiation workers breathe in the section 4 of the appendix 2)
Time of Sampling	November 4, 2011 1:35 pm - 2:35 pm		November 4, 2011 1:35 pm - 2:35 pm				
Detected Nuclides (Half-life)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	
I-131 (about 8 days)	ND	-	ND	-			1E-03
Cs-134 (about 2 years)	1.4E-04	0.07	ND	-			2E-03
Cs-137 (about 30 years)	2.0E-04	0.07	1.8E-05	0.01			3E-03

Place of Sampling	Upper Side of Unit 1 Reactor Building③ (the entrance of the filter in the cover exhaust system)		Upper Side of Unit 2 Reactor Building④ (the exit of the filter in the cover exhaust system)				②Density limit by the announcement of Reactor Regulation (Bq/cm3) (Density limit in the air to which radiation workers breathe in the section 4 of the appendix 2)
Time of Sampling	November 4, 2011 9:08 am - 10:08 am		November 4, 2011 8:56 am - 9:56 am				
Detected Nuclides (Half-life)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	
I-131 (about 8 days)	ND	-	ND	-			1E-03
Cs-134 (about 2 years)	2.5E-05	0.01	ND	-			2E-03
Cs-137 (about 30 years)	3.2E-05	0.01	ND	-			3E-03

Method of Evaluation　Unit 2（1）

Evaluating the discharge amount from the reactor building by multiplying the dust concentration at the blowout panel by the flow rate at the blowout panel.

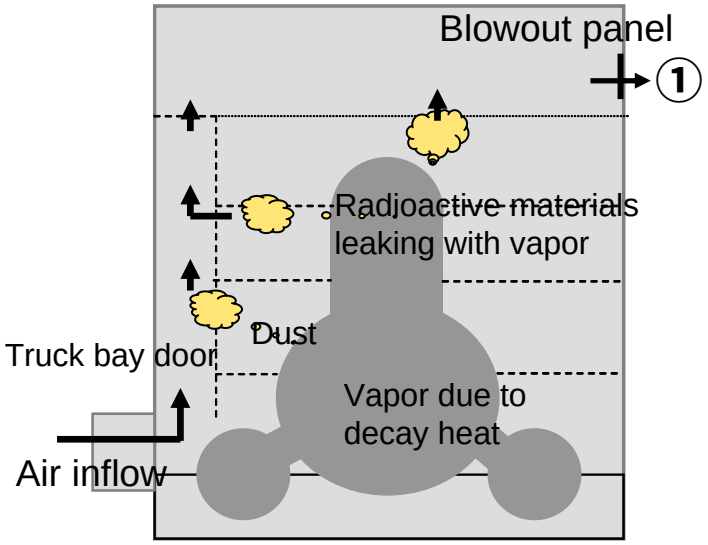
Dust concentration at the blowout panel (Cs-134+Cs-137) X Air flow rate
= Discharge amount from the reactor building…①

*Conducted under the operation of the newly installed primary containment vessel gas management system

Also evaluated the noble gas by the gas at the gateway for system filters and the dust concentration**Considering the impact on the exposure evaluation, only Cs was evaluated for discharge amount.

Discharge amount from
the reactor building of Unit 2 = ①

Measurement at the blowout panel



Method of Evaluation　Unit 2（2）

①Measurement at the blowout panel (on Nov. 1)

Discharge amount (Bq/s)＝ Dust concentration (Bq/cm^3)× Air flow rate at the blowout panel (m^3/s) × 1E6(cm^3/m^3)
=(8.4E-6+7.3E-6)×26.6×1E6 = 4.2E2 Bq/s = **Approx.1.5 million Bq/h**
～(1.8E-5+1.9E-5)×30.2×1E6 = 1.1E3 Bq/s = **Approx. 4.0 Bq/h（→10）**

Measurement at the gateway for the primary containment vessel gas management system (on Nov. 2)

Discharge amount (Bq/s)＝Dust concentration(Bq/cm^3)
× System flow rate (m^3/s)×1E6(cm^3/m^3)
=(2.8E-5+4.3E-5)×0.004×1E6 = 0.28 Bq/s = **Approx. 0.001 million Bq/h**

Noble gas (measured on No. 2)

Discharge amount (Bq/s) = Noble gas concentration (Kr-85)(Bq/cm^3)× System flow rate (m^3/s)×1E6(cm^3/m^3)
=9.5E2×0.004×1E6 = 3.8E6 Bq/s = **Approx. 13,700 million Bq/h（→14,000）**

(Reference) Nuclide analysis results of radioactive materials in the air at the upper side of the Unit 2 R/B

Place of Sampling	At the upside of reactor building of Unit 2① (west side of blow-out panel)		At the upside of reactor building of Unit 2② (north side of blow-out panel)		At the upside of reactor building of Unit 2③ (lower part of blow-out panel)		②Density limit by the announcement of Reactor Regulation (Bq/cm3) (Density limit in the air to which radiation workers breathe in the section 4 of the appendix 2)
Time of Sampling	2011/11/ 1 11:23～13:23		2011/11/ 1 11:23～13:23		2011/11/ 1 11:23～13:23		
Detected Nuclides (Half-life)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	
I-131 (about 8 days)	ND	-	ND	-	ND	-	1E-03
Cs-134 (about 2 years)	1.5E-05	0.01	1.8E-05	0.01	8.4E-06	0.00	2E-03
Cs-137 (about 30 years)	1.7E-05	0.01	1.9E-05	0.01	7.3E-06	0.00	3E-03

Method of Evaluation　Unit 3（1）

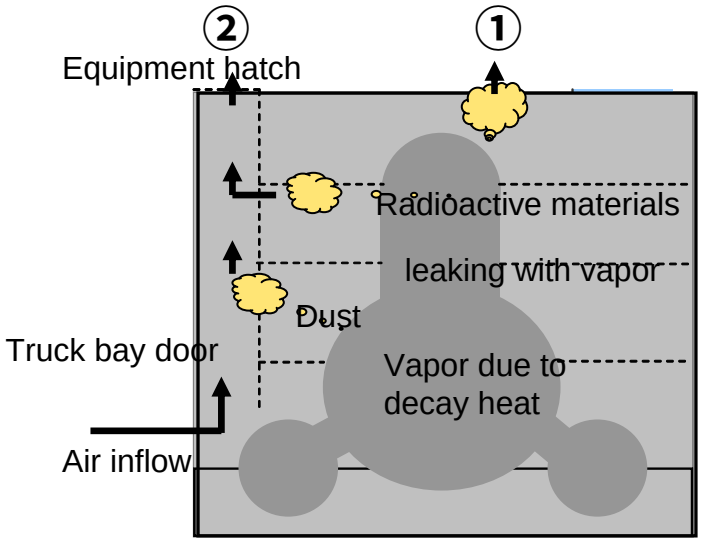
Evaluated the discharge amount by measuring the radioactive materials concentration in the air at each of the measurement points at the upper part of the reactor building.

Dust concentration at the upper part of the reactor building (Cs-134+Cs-137) X Estimated amount of vapor = Discharge amount from the upper part of R/B…①

Dust concentration at the upper part of the equipment hatch (Cs-134+Cs-137) X Air flow rate = Discharge amount from the inside of the Reactor / Building…②

Discharge amount from the reactor building of Unit 3 = ①＋②

Measurement at the upper part of the reactor building



Method of Evaluation　Unit 3（2）

①Upper part of the reactor building (measurement on Nov. 10)

Discharge amount (Bq/s) = Dust concentration (Bq/cm^3) X Estimated amount of generated vapor (m^3/s) X 1E6(cm^3/m^3)
= (4.2E-3+5.0E-3) X 0.58 X 1E6
= 5.3E3 Bq/s
= **Approx. 19.0 million Bq/h**

②Equipment hatch (measurement on Nov. 9)

Discharge amount (Bq/s)=Dust concentration(Bq/cm^3) X Air flow rate of equipment hatch apertural part (m^3/s) X 1E6(cm^3/m^3)
= (1.9E-4+2.3E-4)×(0.31×5.6×5.6)×1E6
= 4.1E3 Bq/s
= **Approx. 15.0 million Bq/h**

Total: Approx. 19.0 million Bq/h + Approx. 15.0 million Bq/h = Approx. 34 million Bq/h（→40.0）

(Reference) Nuclide Analysis Results of Radioactive Materials in the Air at the Upper Part of the R/B of Unit 3

Place of Sampling	Upper part of reactor building of Unit 3⑤(northeast side in upper part of reactor (downward))		Upper part of reactor building of Unit 3⑥(northeast side in upper part of reactor (sideways))		Upper part of reactor building of Unit 3⑦(southeast side in upper part of reactor (downward))		Upper part of reactor building of Unit 3⑧(southeast side in upper part of reactor (sideways))		②Density limit by the announcement of Reactor Regulation (Bq/cm3) (Density limit in the air to which radiation workers breathe in the section 4 of the appendix 2)
Time of Sampling	Nov. 10, 2011 from 12:00 to 12:30		Nov. 10, 2011 from 12:00 to 12:30		Nov. 10, 2011 from 13:00 to 13:30		Nov. 10, 2011 from 13:00 to 13:30		
Detected Nuclides (Half-life)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	
I-131 (about 8 days)	ND	-	ND	-	ND	-	ND	-	1E-03
Cs-134 (about 2 years)	4.2E-03	2.1	1.8E-03	0.90	6.1E-04	0.31	3.5E-04	0.18	2E-03
Cs-137 (about 30 years)	5.0E-03	1.7	2.3E-03	0.77	7.3E-04	0.24	4.5E-04	0.15	3E-03

Place of Sampling	Upper part of reactor building of Unit 3⑤ (northeast side in upper part of reactor (downward))		Upper part of reactor building of Unit 3⑥ (northeast side in upper part of reactor (sideways))		Upper part of reactor building of Unit 3⑦(around machine hatch opening 3rd floor)		②Density limit by the announcement of Reactor Regulation (Bq/cm3) (Density limit in the air to which radiation workers breathe in the section 4 of the appendix 2)
Time of Sampling	Nov. 09, 2011 from 11:25 am to 11:55 am		Nov. 09, 2011 from 11:25 am to 11:55 am		Nov. 09, 2011 from 12:25 am to 12:55 am		
Detected Nuclides (Half-life)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	①density of sample (Bq/cm3)	Scaling Factor (①/②)	
I-131 (about 8 days)	ND	-	ND	-	ND	-	1E-03
Cs-134 (about 2 years)	7.5E-04	0.38	2.1E-03	1.1	1.9E-04	0.10	2E-03
Cs-137 (about 30 years)	9.8E-04	0.33	2.6E-03	0.87	2.3E-04	0.08	3E-03

Result of Evaluation

■The discharge amount by the measurement result at the upper side of the reactor building is calculated by totalizing as follows after rounding up,

Unit 1 : approx. 10 million Bq/h
Unit 2 : approx. 10 million Bq/h
Unit 3 : approx. 40 million Bq/h

Total : approx. 60 million Bq/h

■For the comparison, the amount on the ocean where it is assumed that there is no influence of resuspension of radioactive materials from the ground is measured and estimated, ※

※According to "Guideline for Climate Regarding Safety Analysis of Reactor Facility for Generation" by Nuclear Safety Commission of Japan

On the ocean : approx. 20 Bq/h

■The evaluated value by the measurement result at the upper side of the reactor building is adopted as current discharge amount of Cesium because the amount may fluctuate on the ocean by the change of the wind direction

Discharge amount : approx. 60 million Bq/h

Please see attachment about the evaluation method of exposure dose, discharge amount and radiation dose evaluation.

Result of Evaluation (Attachment)

- Evaluation of exposure dose at site boundary

  It is evaluated that the exposure dose by approx. 60 million Bq/h of discharge amount eqauls to approx. 0.1 mSv/y of exposure dose

  (Method of evaluation)

  Same as usual evaluation, for Cesium, under average climate condition, the radiation dose of each routes are evaluated and totalized,

  - External exposure dose by the radioactive cloud
  - External exposure dose by the radioactive materials accumulated on the ground (measure cause)
  - Internal exposure dose by inhalation

- For noble gas, the discharge amount from Primary Containment Vessel Gas Management System is evaluated as 14 billion Bq/h for Unit 2, and for Unit 1 and 3 it is evaluated as same.

- On the evaluation of exposure dose, for noble gas, because the effective energy of radiated γ ray is small compare with Cesium so that it is only external exposure dose by passing radioactive cloud, therefore for the analysis result of Unit 2, it is evaluated 0.00012 mSv/y.

Future forecast

- We will continue regular measurement of dust concentration at sampling facility on Reactor Building Cover ventilation facility for Unit 1, and upper side of the reactor building for Unit 2 and 3.

- In addition, as the monitoring for discharge of radioactive materials from reactor buildings, for the Primary Containment Vessel, we will also conduct at the exit of Primary Containment Vessel Gas Management System.
- We will study about the method of discharge monitoring concerning the representativeness of measurement point, measurement value and the change of site situation by removal of debris and so on, and continue to evaluate discharge amount properly, and confirm that the discharge is suppressed and the level is decreasing.

<Reference> Method of Evaluation (on the ocean)

To sample in case that the sampling point located on the leeward of discharge source (reactor building)

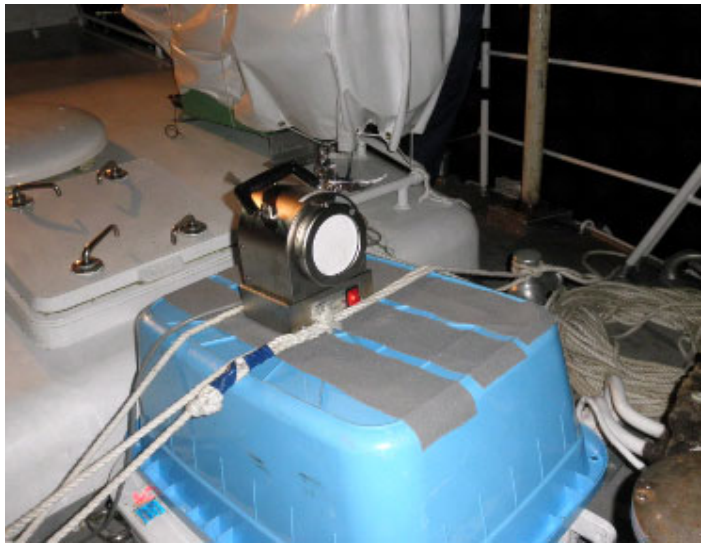
To measure of radioactive material density in the air by the research ship at the point about 2 km offshore on the leeward of Unit 1-3.

To assume the discharge amount from reactor building from radioactive material density in the air by the basic diffusion function (“Guideline for Climate Regarding Safety Analysis of Reactor Facility for Generation” by Nuclear Safety Commission of Japan

- Dust concentration (Max. sampled on Nov.11) :
  - Cs-134 3.2E-8 Bq/cm3
  - Cs-137 3.2E-8 Bq/cm3
- Climate condition :
  - West wind, wind velocity 2.0～2.7 m/s
  - Stability of atmosphere D
- Result of evaluation :

Approx. 15 million Bq/h （→20）

Measurement of radioactive material density in the air on the ship



Measurement of radioactive material density in the air