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Guide for Radiation Monitoring of Effluent Released
from Light Water Nuclear Power Reactor Facilities

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Disclaimer

This is an unofficial translation of the official Nuclear Safety Commission Regulatory Guide for the benefit of interested readers. For all questions regarding meaning and phrasing, please refer to the official version in Japanese.

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Guide for Radiation Monitoring of Effluent Released from Light Water Nuclear Power Reactor Facilities

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I . Objective

This Regulatory Guide lays down standard method to monitor radioactive level of radioactive materials contained in air-borne wastes and liquid wastes released into the environment during normal operation at light water nuclear power reactor facilities.

The monitoring method set forth in this Regulatory Guide is based on current monitoring techniques and experiences and should be revised embracing the developments of monitoring techniques.

In addition, provided that an alternative method, which does not conform to this Regulatory Guide, is well-grounded, the method should not be ruled out.

This Regulatory Guide is applied to light water nuclear power reactor facilities, however, it serves as a reference to monitoring techniques for target nuclides at other nuclear facilities.

II . Target nuclides for monitoring, minimum detection limit on concentration and monitoring frequency

Air-borne radioactive materials and liquid radioactive materials released from light water nuclear power reactor facilities should be monitored according to target nuclides set for monitoring, minimum detection limit on concentration and monitoring frequency, which are shown in Table-1 respectively, taking into consideration release conditions, physical and chemical properties of radioactive materials and release control techniques.

Table-1 Target nuclides for monitoring, required detection limit and minimum monitoring frequency, applied to released radioactive materials

State of released material	Target nuclides for monitoring		Required detection limit (Bq/cm ³)	Minimum monitoring frequency
	Properties	Radioactive nuclides		
Airborne	Gaseous materials	Radioactive noble gases	2×10^{-2}	Continuous
	Volatile materials	Iodine-131	7×10^{-9}	Once a week
		Iodine-133	7×10^{-8}	Once a week
		Tritium	4×10^{-5}	Once a month
	Particulates	γ emitters such as Chrome-51, Manganese-54, Iron-59, Cobalt-60, Cesium-134 and Cesium-137	4×10^{-9} ※1	Once a week
		Strontium-89, Strontium-90	4×10^{-10} ※2	Once a quarter
		Total β activity	4×10^{-9}	Once a month
		Total α activity	4×10^{-10}	Once a month
Liquid	γ emitters such as Chrome-51, Manganese-54, Iron-59, Cobalt-58, Cobalt-60, Iodine-131, Cesium-134 and Cesium-137	2×10^{-2} ※1	At every discharge or once a week	
	Strontium-89, Strontium-90	7×10^{-4} ※2	Once a quarter	
	Tritium	2×10^{-1}	Once a month	
	Total β activity	4×10^{-2}	Once a month	
	Total α activity	4×10^{-3}	Once a month	

* 1 Value for Cobalt-60 is indicated as representative.

* 2 Value for Strontium-90 is indicated as representative.

III. Sampling method

Samples should be taken by using techniques allowing them to represent the concentration of radioactive materials released, taking into consideration the kind of radial rays emitted from radioactive materials, physical and chemical properties of radioactive materials, radioactivity detection techniques and minimum detection limit on concentration. In

addition, sampling equipments should be provided with arrangements to allow continued sampling in case of equipment failures.

1. Airborne radioactive materials released

1.1 Sampling frequency and sampling point

- (1) In principle, samples should be taken without interruption.
- (2) In principle, sampling point should be located in the outermost duct or stack.

1.2 Arrangements for sampling nozzle and its shape

- (1) Sampling nozzle should be installed at the position where airborne radioactive materials released is fully mixed and, if necessary, should have redundant nozzles.
- (2) Sampling nozzle size/shape should be determined considering sampling volume, air velocity inside the outermost duct or stack.
- (3) In principle, air velocity at sampling nozzle should be equal to air velocity inside the outermost duct or stack.

1.3 Structure of sampling pipes

To prevent radioactive material from depositing inside sampling pipes, pipes should be as short as possible and have less sharp bends, adopting materials inhibiting deposits of radioactive materials.

1.4 Sampling methods and sampling equipments

- (1) Gaseous materials should be continuously directed into monitoring container and should be monitored directly by radiation detector. The volume of monitoring container should be large enough to ensure minimum detection limit on concentration, taking consideration the performance of radioactivity counting equipment.
- (2) Volatile materials should be collected by using capture materials such as charcoal cartridge. In addition, capture materials should be so selected as to have suitable capture

efficiency, which renders particular correction needless, taking into consideration physical and chemical properties and filtering velocity. In addition, sampling volume of the air should be large enough to ensure minimum detection limit on concentration, considering the performance of radioactivity counting equipment. As an alternative sampling method, condensing techniques through cooling can be used for capturing tritium.

(3) Airborne particles should be captured by dust chamber filter. Dust chamber filter should be so selected as to have suitable capture efficiency, which renders particular correction needless, taking into consideration physical and chemical properties, particle size composition and filtering velocity.

In addition, sampling volume of the air should be large enough to ensure minimum detection limit on concentration, considering the performance of radioactivity counting equipment.

1.5 Frequency for replacing capture materials

Capture materials should be replaced frequently enough to prevent sharp drop in capture efficiency and obstructive clogging.

2. Liquid radioactive materials released

2.1 Sampling frequency and sampling point

- (1) Samples should be taken every time when liquid radioactive materials are released.
- (2) Sampling point should be in the outermost tank of discharge system.

2.2 Tank and piping

The discharge system's outermost tank, where samples are taken, should be equipped with mixer to allow for taking representative samples. To prevent radioactive material from depositing inside sampling pipes, sampling pipes should be as short as possible and should have a capability to be well-rinsed before taking samples.

2.3 Sampling volume

Sampling volume should be large enough to ensure minimum detection limit on concentration, considering the performance of radioactivity counting equipment. In addition, provided that composite sample is prepared to detect long half-life nuclides, samples should be taken in proportion to respective discharge volume.

IV. Radioactivity counting

1. Airborne radioactive materials released

(1) Radioactive noble gases should be continuously counted, whether it is off-line or in-line, by using NaI(Tl) scintillation counter, ionization chamber, plastic scintillation counter or GM counter. However, provided that radioactive materials are released from storage tank after being decayed in radioactivity, it is allowed to determine released radioactivity from counting samples taken from storage tank.

(2) Iodine-131 and Iodine-133 should be counted by using Ge-semiconductor detector coupled with multi-channel pulse height analyzer (hereinafter referred to as “Ge-semiconductor spectrometer”), immediately after taking samples.

(3) Tritium should be counted by using liquid scintillation counter.

(4) Radioactive materials contained in particulates should be counted as follows:

① Nuclides that emit γ ray should be counted by Ge-semiconductor spectrometer immediately after taking samples.

② Strontium-89 and Strontium-90 should be counted by GM counter after radio-chemical separation from samples.

③ Total β activity is counted by gas-flow GM counter or gas-flow proportional counter as raw samples or after being properly processed.

④ Total α activity is counted by gas-flow proportional counter or ZnS(Ag) scintillation

counter as raw samples or after being properly processed.

2. Liquid radioactive materials released

(1) As for nuclides that emit γ ray, each sample, which was taken every time radioactive wastes are released, or a composite sample should be counted by Ge-semiconductor spectrometer.

(2) As for Strontium-89 and Strontium-90, a composite sample should be prepared from collected samples and, after radiochemical separation, should be counted by GM counter.

(3) As for tritium, a composite sample should be prepared from collected samples and, after suitable processing, should be counted by liquid scintillation counter.

(4) As for total β radioactivity, a composite sample should be prepared from collected samples and, after suitable processing including evaporation to dryness, should be counted by gas-flow GM counter gas-flow proportional counter.

(5) As for total α radioactivity, a composite sample should be prepared from collected samples and, after suitable processing including evaporation to dryness, should be counted by gas-flow proportional counter or ZnS(Ag) scintillation counter.

3. Calibration of radiation counters

3.1 Calibration methods

Radiation counter should be calibrated by using suitable standard radiation sources or calibration sources (hereinafter referred to as “standard source etc.”). Standard source etc. should include nuclides similar to target nuclides or other nuclides emitting rays whose energy range covers target energy. The shape of standard source etc. should be the same as, or similar to, that of samples to be counted.

(1) Radioactive noble gases counter should be calibrated by counting actual samples and

correlating counter count rate (cps) or ionization current (A) with the total sum of radioactivity concentration (Bq/cm³) obtained for each nuclide by Ge-semiconductor spectrometer.

However, provided that radioactivity concentration of actual samples is too low to get results for each nuclide, radioactive noble gas counter should be calibrated by deriving counter-specific counting efficiency or energy dependent ionization efficiency, based on standard source etc. counting, and estimating nuclide composition of samples in a suitable way.

(2) Radiation counters for nuclides other noble gases should be calibrated by using standard source etc. with geometrical shape similar to actual samples. Prior to this, energy-dependent counting efficiency (peak efficiency) of Ge-semiconductor spectrometer should be derived in a similar way to (1). Counters for Strontium-89, Strontium-90 and tritium should be calibrated using standard source etc. corresponding to target nuclides.

(3) Radiation counters for total β and total α activity should be calibrated by using suitable β standard source etc. and α standard source etc.

3.2 Calibration frequency

Counting efficiency and ionization efficiency should be measured at least one a year.

4. Background level and sensitivity limit

4.1 Counting of background level

Background level of counters should be grasped at appropriate intervals.

4.2 Calculation of sensitivity limit

Sensitivity limit of counters should be derived based on background level in actual working conditions.

V. Calculation of released radioactivity

Released radioactivity should be calculated using conversion factors to amount or concentration of radioactive materials, released amount and correction coefficients, leaving out count results lower than sensitivity limit of radiation counters.

1. Deduction of background value

Net counts should be calculated by deducting background value from sample counts measured by radiation counters. Units of counts should be count rates (cps) or ionization current (A).

2. Conversion factors

Conversion factors should be derived for nuclides of concern to convert counts (cps or A) into radioactivity concentration (Bq/cm^3) using calibration results shown in IV-3 and sample volume.

Regarding radioactive noble gases, provided that radioactivity concentration of actual samples is too low to get results for each nuclide, conversion factors should be derived estimating nuclide composition of samples in a suitable way, based on counting efficiency or energy dependent ionization efficiency, which were derived in. IV3.1.(1).

3. Correction

3.1 Correction for radioactive decay

(1) Radioactive decay during the periods for sampling and preparation of composite samples should be corrected assuming radioactive concentration was constant throughout those periods despite radioactive decay.

(2) Radioactive decay during counting as well as the period between sampling and the

beginning of counting should be appropriately corrected based on time records.

3.2 Other corrections

Provided that radioactive noble gases are measured by the use of offline method, correction should be made in the pressure of container counted.

4. Calculation of detection-limit concentration

Detection-limit concentration should be calculated based on counter sensitivity limit shown in. IV4.2.

VI. Recording

1. Recording of counting results

In addition to counting results, should be recorded pieces of useful information to confirm counting conditions.

2. Aggregation of counting results

Released radioactivity should be aggregated as shown in Table-2 except for total β activity, which should be aggregated if necessary.

Table-2 Data aggregation periods

State of released material	Target nuclides for monitoring		Data aggregation periods					
	Properties	Radioactive nuclides	Day	Week	Month	Quarter	Year	
Airborne	Gaseous materials	Radioactive noble gases	○		○	○	○	
	Volatile materials	Iodine-131		○	○	○	○	
		Iodine-133		○	○	○	○	
		Tritium			○	○	○	
	Particulates	γ emitters such as Chrome-51, Manganese-54, Iron-58, Cobalt-60 and Cesium-134			○	○	○	○
			Strontium-89, Strontium-90				○	○
Total α activity					○	○	○	
Liquid		γ emitters such as Chrome-51, Manganese-54, Iron-59, Cobalt-58, Cobalt-60, Iodine-131 and Cesium-134	○	*	○*	○*	○*	
		Strontium-89, Strontium-90				○	○	
		Tritium			○	○	○	
		Total α activity			○	○	○	

* Data aggregation for composite samples