Radiation monitoring in the environment of nuclear power plants

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Authorisation

By virtue of section 55, second paragraph, point 3 of the Nuclear Energy Act (990/87) and section 29 of the Council of State Decision (395/91) on General Regulations for the Safety of Nuclear Power Plants, the Finnish Centre for Radiation and Nuclear Safety (STUK) issues detailed regulations concerning the safety of nuclear power plants.

YVL Guides are rules an individual licensee or any other organisation concerned shall comply with, unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. This Guide does not alter STUK's decisions which were made before the entry into force of this Guide, unless otherwise stated by STUK.

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1 General

The use of nuclear energy is prescribed in the Nuclear Energy Act (990/87) and in the Nuclear Energy Decree (161/88). By virtue of section 81 of the Nuclear Energy Act, the Council of State has issued general regulations for the safety of nuclear power plants (395/91). The Radiation Act (592/91) and the Radiation Decree (1512/91) set forth general regulations for the limitation of radiation exposure.

The operation of nuclear powr plants yields radioactive substances which mainly remain in the nuclear fuel, the reactor cooling circuit, the water and gas treatment systems of the plant and the waste systems. Only a very small fraction of these radioactive substances are released from the plant to the environment.

According to section 7 of the Council of State Decision (395/91), "Radiation exposure arising from the operation of a nuclear power plant shall be kept as low as reasonably achievable. A nuclear power plant and its operation shall also be designed so that the limits presented in this decision are not exceeded."

Section 9 of the Decision states: "The limit for the dose commitment of an individual of the population, arising from normal operation of a nuclear power plant during one year, is 0.1 mSv. Based on this limit, release limits for radioactive materials during the normal operation of a nuclear power plant are to be defined."

Sections 10–12 of the Decision present the limits for an anticipated operational transient, a postulated accident and a severe accident. These limits shall especially be taken into account in technical solutions related to the safety of the nuclear power plant.

According to section 26 of the Decision, "Releases of radioactive materials from a nuclear power plant and their concentrations in the environment shall be effectively monitored." Monitoring of the amount of radioactive substances and the radiation situation in the environment of the nuclear power plant is called environmental radiation monitoring. According to section 36, point 9 of the Nuclear Energy Decree, the applicant shall submit a programme for radiation monitoring in the environment of the nuclear facility to the Finnish Centre for Radiation and Nuclear Safety (STUK) when applying for an operating licence.

This Guide presents detailed requirements for environmental radiation monitoring around a nuclear power plant. A nuclear power plant includes all nuclear facilities on the same site.

Requirements for the limitation of public exposure in the environment of nuclear power plants and the limitation of radioactive releases from the plants are presented in Guide YVL 7.1. Requirements for the evaluation of population doses in the environment of nuclear power plants and the evaluation of the distribution of radioactive releases from nuclear power plants under operating and accident conditions are presented in Guides YVL 7.2 and YVL 7.3. Guides YVL 7.6 and YVL 7.8 address the monitoring of radioactive releases from nuclear power plants and the nuclear power plant environmental radiation safety reports to be submitted to STUK. Guide YVL 7.4 deals with nuclear power plant emergency planning.

2 Radiation monitoring in the environment of nuclear power plants

2.1 General principles

The licensee is responsible for monitoring radioactivity in the environment of the plant and shall have sufficient expertise available. The monitoring of radioactivity in the environment of the nuclear power plant includes radiation measurements on the plant site and in its environment and analyses of radioactive substances carried out to determine the radiation exposure of the population and the amount of radioactive substances present in the environment.

Environmental monitoring is focused on man and the environment. The data obtained by environmental monitoring can be utilised when informing the public about the safety and environmental effects of nuclear power plants.

The objective of environmental radiation monitoring is to ensure that the radiaction exposure of the population arising from the operation of the nuclear power plant is kept as low as reasonably achievable and that the limits set forth in regulations are not exceeded. Further, with the help of the monitoring, potential short and long term changes in the normal radiation situation of the environment are detected. Monitoring is also used to verify the results of measurements of radioactive releases from the nuclear power plant and the models used for estimating the distribution of the releases.

Radiation monitoring shall be regular and well defined. It shall take into account the specific characteristics of the plant site and its environment and also earlier experience gained in the operation of the plant and in the radiation monitoring of its environment.

In radiation monitoring, provision shall be made for operation even in the event of an accident.

2.2 Environmental radiation monitoring programme

The environmental radiation monitoring programme shall specify who implements the programme. It shall also specify the implementation of samplings and measurements including their frequency. Also the following shall be described: methods and equipment for measurements and samplings, sample and nuclide specific detection limits, testing of instruments as well as handling and recording of the measurement data.

The programme shall include external radiation measurements, as well as determination of radioactive substances in air, in samples representing different parts of food chains of man and determinations of the internal radioactivity in man.

When defining the contents of the programme, special attention shall be paid to significant release periods and routes and nuclides as well as to the radiation exposure caused by the releases. The programme shall also include so called indicator samples (organisms and substances which accumulate or enrich radionuclides discharged). In addition to regular samplings and measurements, special investigation of the environment of the plant shall be made. These are required, for example, to further develop the programme.

Radiation measurements shall be made and samples shall be taken representatively within a distance of several kilometres from the plant, taking into account the local spreading conditions, and the location and living habits of the local population. Samples of food stuffs shall be taken at production and processing plants closest to the nuclear power plant. Monitoring shall also include verification measurements taken at the discharge point and in its immediate vicinity.

In the terrestrial environment, analyses of radioactive substances in food chains shall primarily be focused on the analysis of radioactive substances in

— deposition
— soil
— drinking water
— grain and garden produce
— natural produce and plants
— meat
— grazing grass and milk.

In the aquantic environment, the analyses of radioactive substances shall be focused on

— sea water
— sinking matter and bottom sediments
— aquatic plants and benthic animals
— fish.

The radioactivity measurements of samples taken for radiation monitoring purposes shall be so performed that the amounts of individual radionuclides can be analysed with sufficient accuracy. The determination of radioactivity is based on spectrometric measurement and, if necessary, on a chemical separation of the radionuclide to be measured. The radionuclides to be measured from the samples shall first be enriched, if necessary.

The radiation monitoring programme shall be so implemented that sufficient data is also obtained about radioactive substances in the environment originating from sources other than the nuclear power plant in question. In defining the origin of these substances, reference data obtained by general radiation monitoring in Finland can be used, as applicable. Further, when planning the radiation monitoring programme, data about radioactive substances in the systems of the nuclear power plant can be taken into account as well as data about the releases of these substances during operational, transient and accident situations.

The radiation monitoring programme shall be planned to maintain sufficient preparedness to carry out the necessary measurements also during accidents.

Regularly analysed dose meters shall be placed in the plant's terrestrial environment to monitor external radiation and also a sufficient number of continuously operating, reliable dose rate measuring stations from which the measurement data are transmitted to the nuclear power plant and to the national radiation monitoring network. Accurate gross dose rate measurements and gamma-spectrometric measurements shall also be regularly performed in the the plant's environment.

The contents and implementation of the radiation monitoring programme shall be revised as needed, at least every five years. Earlier experiences, and advances in monitoring methods shall then be taken into account.

An example of a nuclear power plant's environmental radiation monitoring programme is given in the Annex.

The licensee shall maintain a database of the results of analyses of environmental samples at least until the expiration of the operating licence.

2.3 Clarification and follow-up of an exceptional situation

The results of environmental radiation monitoring which deviate from normal must be verified and the cause of the deviation clarified. The radiation monitoring programme may require updating. The need for updating is assessed case by case.

3 Regulatory control

The licence-applicant/holder shall obtain an approval from the Finnish Centre for Radiation and Nuclear Safety for the environmental radiation monitoring programme.

Instructions for the implementation of the monitoring programme shall be submitted to the Centre for information.

The results of radiation monitoring shall be reported to the Centre according to Guide YVL 7.8.

The Finnish Centre for Radiation and Nuclear Safety regularly inspects environmental monitoring as part of the on-site regulatory control. Independent reference measurements are also performed, if necessary.

4 References

ICRP Publications 43, "Principles of Monitoring for the Radiation Protection of the Population" Vol 15 No 1 (1985).

IAEA Safety Series 41, "Objectives and Design of Environmental Monitoring Programs for Radioactive Contaminants" (1975).

ANNEX

An example of an environmental radiation monitoring programme

Object to be monitored	Number of measuring equipment or samples and stations of measurement and sampling	Sampling frequency (number/year)	Analysis and frequency
1. External radiation	At least four radiation dose rate meters on-site (or in the plant's vicinity) and 10 dose rate meters off-site at a distance of about 5 km from the plant in the direction of population	—	Continuous measurement and recording
	10–20 dosemeter stations evenly located in the most important directions from the plant at a distance of 1–10 km	4/a	Gamma dose, 4/a
	Supplementary monitoring performed with gross dose rate and gamma spectrometric measurements	1/2a	Gamma dose, gamma spectrum 1/2a
2. Airborne radioactive particulates and iodine	3–5 air samplers located at a distance of 1–10 km from the plant	Continuous sampling, filters replaced 2/month except during annual maintenance 1/week from the closest sampler	Gamma emitters, 2/month (1/week)
	Supplementary monitoring, when needed, using a movable air sampler (e.g. during annual maintenance)	2–6/a	Gamma emitters, 2–6/a
3. Deposition	3–5 rain water collectors located at a distance of 1–10 km from the plant	Continuous collection 4–12/a	Gamma emitters and ^{3}H, 4–12/a, ^{89}Sr ja ^{90}Sr, 4/a normally just from the closest and the farthest collectors
4. Soil	Sampling from the assumed main area of deposition	1/4a	Gamma emitters and ^{90}Sr
5. Indicator organisms	1–4 indicator species that effectively enrich radionuclides	1–2/a	Gamma emitters 1–2/a and ^{89}Sr and ^{90}Sr, 1/a
6. Gathered food products and game	10 samples from the area within 0–10 km from the power plant according to the local harvest/catch	1/4a	Gamma emitters

An example of an environmental radiation monitoring programme

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Object to be monitored	Number of measuring equipment or samples and stations of measurement and sampling	Sampling frequency (number/year)	Analysis and frequency
7. Grazing grass	At a distance of 0–10 km from the power plant	2/a	Gamma emitters, 2/growing season
8. Milk	Sample representative of farms located at a distance of 0–10 km from the power plant. Sample representing the milk production of a local dairy (less than 40 km from the power plant).	1/week	^{131}I, 1–2/month, gamma emitters 1/month. ^{89}Sr and ^{90}Sr, 2–6/a. Iodine analysis of milk produced only in the vicinity, Sr-analysis from samples at the distance of only 0–40 km
9. Garden produce	At a distance of 1–10 km from the power plant 2–3 species	1–2/a	Gamma emitters, 1–2/a
10. Grain	1–2 species at a distance of less than 20 km from the power plant	1/a	Gamma emitters, ^{89}Sr and ^{90}Sr, 1/a
11. Meat	1–2 species at a distance of less than 40 km from the power plant	2/a	Gamma emitters, 2/a
12. Drinking water	From the power plant and from a major population centre in the surrounding area	4/a	Gamma emitters and ^{3}H, 4/a, ^{89}Sr and ^{90}Sr, 2/a
13. Sea water	At 4–5 sampling stations	2–4/a	Gamma emitters as well as ^{3}H, ^{89}Sr and ^{90}Sr, only from the nearest and the reference point
14. Indicator organisms in the marine environment	2–6 indicator species from 1–5 areas	1–2/a	Gamma emitters 1–2/a, ^{89}Sr and ^{90}Sr, ^{238}Pu and ^{239,240}Pu only from the nearest and the reference station

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An example of an environmental radiation monitoring programme

Object to be monitored	Number of measuring equipment or samples and stations of measurement and sampling	Sampling frequency (number/year)	Analysis and frequency
15. Fish	2–4 species in household use and with different living habits caught from the discharge area and the reference area	2/a	Gamma emitters, 2/a ^{89}Sr and ^{90}Sr from two species 1/a
16. Sinking matter	From 3–6 stations	Continuous collection, 3–6/a	Gamma emitters, 3–6/a, ^{238}Pu and ^{239,240}Pu only from the nearest and the reference point 1/a
17. Bottom sediments	Sampling from sedimentation areas in the main directions of discharge	1/4a	Gamma emitters, ^{90}Sr and ^{239,240}Pu, vertical distribution
18. Man	Whole-body counting of 8–15 individuals living in the plant's vicinity		1/2a