Monitoring of occupational exposure at nuclear power plants

This Guide is in force as of 1 October 1994 until further notice. This Guide replaces Guide YVL 7.10, issued 1 March 1984.

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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 by the Nuclear Energy Act (990/87) and by the Decree (161/88) issued by virtue of it. Also the provisions of section 2 and chapter 9 (radiation work) of the Radiation Act (592/91) are applied to the use of nuclear energy.

According to section 2 of the Radiation Act, to be acceptable, the use of radiation and practices involving exposure to radiation shall meet the following criteria:

1) The benefits accruing from the practice shall exceed the detriment it causes (principle of justification).
2) The practice shall be organised in such a way that the resulting exposure to radiation hazardous to health is kept as low as is reasonably achievable (principle of optimisation);
3) No person's exposure to radiation shall exceed the maximum values prescribed by decree (principle of limitation).

Essential regulations concerning the radiation exposure of individuals are presented in the Radiation Act and Decree (1512/91). The aim of these regulations is to protect individuals from the hazardous effects of radiation.

This Guide deals with the monitoring of doses of nuclear power plant workers and the reporting of radiation doses to the Finnish Centre for Radiation and Nuclear Safety. Guide YVL 7.9 deals with radiation protection of nuclear power plant workers during operation of the plants. Guide ST 1.7 [1] presents health monitoring requirements relating to radiation work.

Guide ST 1.2 [2] specifies the quantities and units used in the determination of radiation exposure. Guide ST 1.5 [3] presents annual limits on intake of radionuclides to be followed in the monitoring of internal dose and also limits for the concentrations of radionuclides in breathing air. Guide ST 1.6 [4] sets forth instructions for monitoring of radiation exposure and recording of doses.

2 Essential provisions of the Radiation Act and Decree

According to section 32 of the Radiation Act, the responsible party shall organise monitoring of radiation exposure and of related working conditions at the place of work to whatever extent is required by the nature and scope of the practice.

Dose limits to persons engaged in radiation work are specified in sections 3 and 4 of the Radiation Act. The measures needed to restrict radiation exposure in an accident situation are prescribed in section 8 of the Decree.

According to section 9 of the Radiation Decree, if the effective dose at work, including the possibility of a work-related occurrence leading to exceptional radiation exposure in the course of work, is or may be higher than 5 mSv a year, the radiation exposure shall be monitored at the workplace.

According to section 10 of the Radiation Decree, the responsible party shall make sure that data on persons engaged in radiation work and the results of exposure monitoring are recorded and reported to Finnish Centre of Radiation and Nuclear Safety for inclusion in the Dose Register. If it is found or suspected that a dose limit specified in sections 3–6 of the Radiation Decree has been exceeded, the Finnish Centre for Radiation and Nuclear Safety shall be notified without delay.

According to section 11 of the Radiation Decree, working conditions affecting radiation exposure shall be determined and monitored at the workplace in such a way that undue radiation exposure can be detected and prevented. According to section 12 of the Decree, methods and equipment used for monitoring radiation exposure and

the relevant working conditions are subject to approval by the Finnish Centre for Radiation and Nuclear Safety.

The handing over of data contained in the Dose Register of the Finnish Centre for Radiation and Nuclear Safety is prescribed in section 34 of the Radiation Act. The provisions of the Act on Personal Data Registers (471/87) and the Decree on Personal Data Registers (476/87) also apply to the dose registers of nuclear power plants.

3 Monitoring of radiation exposure

3.1 General requirements

The licence-holder is responsible for arranging the measurement of external occupational dose and the determination of dose arising from the intake of radioactive substances at the nuclear power plant in a way approved by the Finnish Centre for Radiation and Nuclear Safety.

The radiation exposure of all persons in the controlled area (see Guide YVL 7.9) shall be monitored. Those working in the controlled area shall carry a personal external radiation dosimeter on the basis of which radiation doses to workers are determined and are regularly entered in the dose register. Previously incurred radiation doses must be known before new work is started so as not to exceed the dose limits.

Assessment of the circumstances of exposure requires that the nuclear power plant has measuring equipment and arrangements for measuring work-specific external dose rate and for determining potential surface contamination and the concentration of radionuclides in air. The determination of any potential intake of radioactive substances by workers and the measurement of surface contamination on the skin and on the protective equipment of those leaving the controlled area shall be arranged.

Apart from personal dosimeters, the nuclear power plant shall have a system for continuously monitoring the accumulation of individual dose arising from external radiation in work from which a significant dose may be incurred. The system shall also enable efficient work-specific dose monitoring.

Any potential intake of radioactive substances shall be kept so low that the dose incurred (internal dose) clearly remains below the dose limits. Continuous monitoring of individual dose is not generally relevant. However, the nuclear power plant shall have sufficient arrangements for detecting any intake of radioactive substances.

3.2 Monitoring of work-specific dose and of working conditions

Occupational dose monitoring shall be used to control work-specific exposure to radiation, to collect data for the planning of work and to ensure that work-specific radiation protection measures are sufficient. The dosimeters used in dose monitoring shall be equipped with a display and a dose alarm threshold that can be set. The system must facilitate daily monitoring of work-specific and individual external dose.

Factors affecting work-specific exposure shall be monitored, e.g. external dose rate, surface contamination and the radionuclide concentration of air. On the basis of these factors, the protective equipment to be used in work, as well as any potential additional dosimeters, shall be determined.

Data required for the determination of dose based on internal activity shall be recorded, e.g. the data in a work permit, work-specific data on increased surface contamination and radionuclide concentration of air, and also data on any individual contamination requiring radical decontamination measures.

3.3 Recording of radiation doses

The results of dose measurements of persons working in the restricted area shall be recorded and sent to the Finnish Centre for Radiation and Nuclear Safety for inclusion in the Centre's Dose Register. The licence-holder is responsible for monitoring the doses of those working in the restricted area irrespective of their employer.

Dosimetry measurement data, dose data derived from them and data on the calculating method and the quantity to be measured shall be recorded.

The employee shall be given the data about his radiation doses on request. The licence-holder shall deliver to the employer of a temporary worker a monthly notification of the doses received by the worker.

What is said above also applies to doses received by foreign workers. The doses received by Swedish workers shall be entered also in the central dose register of the Swedish nuclear power plants.

4 Measurement of external dose

The system for measuring individual dose arising from external radiation and the related calibration and quality assurance procedures shall have the approval of the Finnish Centre for Radiation and Nuclear Safety. International standards and recommendations shall be observed for applicable parts in the system's design and use [5, 6, 7].

Data required in dose determination shall be reliably maintained in the dosimeter for the duration of the entire measurement period. The dosimeters and their racks shall be provided with identification numbers. Dosimeters in permanent use shall be provided with an identification number and the user's name.

Workers in the controlled area shall wear a personal dosimeter in a manner facilitating representative and visible measurement of radiation dose. Besides the personal dosimeter, additional dosimeters shall be used if various parts of the body will be unevenly exposed to radiation and if effective dose may significantly deviate from the reading of the personal dosimeter. Appropriately placed additional dosimeters shall also be used whenever the dose to the skin or the eyes may significantly exceed the dose reading of the personal dosimeter.

Persons on a guided visit to the lowest zone of the controlled area can be given a group-specific dosimeter (see Guide YVL 7.9) to register doses incurred by the group.

The maximum length of a personal dosimeter's measurement period shall not exceed one month.

The personal dosimeter shall distinguish between depth dose and surface dose [2], it shall be capable of reliably measuring depth dose arising from gamma radiation within the range 0.1 mSv–1 Sv when photon energy is from 80 keV to 3 MeV, and it shall also be capable of detecting neutron doses.

Work which may involve a dose in excess of the recording threshold shall be monitored for neutron dose. Fuel transfers are an example of such work. Dose measurement by separate neutron dosimeters shall be arranged whenever it is assessed that occupational dose arising from neutron radiation can exceed 0.5 mSv in a month.

Personal dosimeters shall be kept at the entrance of the controlled area or in some other way approved by the Finnish Centre for Radiation and Nuclear Safety
— to monitor their use
— to minimise their exposure to background radiation, ultraviolet radiation and strong light
— to avoid reduction in the quality of measuring arrangements due to humidity or temperature of the dosimeter racks

— to facilitate dosimeter reading and periodical checking for surface contamination.

Dosimeters other than those of the nuclear power plant can be taken to the controlled zone only if it has been ensured that individual doses are not recorded twice in the dose register.

5 Determination of internal dose

Dose in this connection means the accumulated effective dose during a period of 50 years arising from the intake of radioactive substances [2, 8].

For the determination of internal dose, the nuclear power plant shall be provided with equipment for monitoring internal activity which is capable of detecting from the upper body area any activity of ^{60}Co which is a hundredth part of the annual limit for intake. Those working in the controlled area during an annual maintenance outage shall, as a rule, be checked with this equipment when their work is accomplished. The measurement requirement also applies to other outages or repairs which may involve the intake of radioactive substances by humans.

Internal radiation shall also be measured whenever measurements to detect contamination of the skin or protective clothing of those leaving the controlled area, or some other observation, indicate internal contamination deviating from what is normal may have occurred.

If, on the basis of the measurements, exceptional individual internal exposure is detected, also other workers on the same assignment shall be measured for internal radiation, as deemed necessary.

Also the below groups shall be monitored

— a pre-selected group of the nuclear power plant's permanent staff assessed to run the greatest risk of internal contamination, and
— to control internal doses caused by annual maintenance and refuelling, a group selected so that it represents each class of work having the greatest risk of internal contamination and represents all the single work performances exposing workers to contamination.

Gamma activity measurement equipment capable of distinguishing between different radionuclides shall be used for the monitoring. A sufficient number of workers shall be chosen for the groups to obtain representative data on internal doses and contamination. Excretion or other biological samples shall be used, if necessary, for assessment of internal dose. The time of the measurements shall be so chosen that potential contamination is best detected.

Dose arising from the intake of radioactive substances shall be assessed on the basis of measurements and the postulated time and mode of exposure [9] and using a calculation method approved by the Finnish Centre for Radiation and Nuclear Safety.

6 Reporting of radiation doses

Once a month, the licence-holder shall report the individual external doses of workers who have been engaged in radiation work and are subject to dose monitoring, for inclusion in the Dose Register of the Finnish Centre for Radiation and Nuclear Safety. At the same time, the personal details of workers subject to dose monitoring, as well as what work they did and when it was started and accomplished shall be reported.

Internal doses shall be reported to the Finnish Centre for Radiation and Nuclear Safety within a month from the day the internal activity was observed.

The recording level for a depth dose is 0.1 mSv. Doses below this level shall be reported to the Dose Register as zero doses.

Surface dose shall be reported to the Dose Register separately if it exceeds the simultaneous depth dose by one third part.

The neutron doses measured shall be reported to the Dose Register separately.

Doses caused by internal radiation shall be reported to the Dose Register if, on the basis of body activity measurements, the assessed dose commitment exceeds 0.1 mSv. The method of assessing doses exceeding the reporting threshold and a description of the exposure situation and circumstances shall be sent to the Finnish Centre for Radiation and Nuclear Safety for information.

Nuclear power plant operational reports shall give the dose data required in Guide YVL 1.5.

7 Actions and reporting in exceptional situations

All events in which the worker dose limit is noted to have been exceeded, or it is not clear what individual doses have been incurred, shall be notified without delay to the Finnish Centre for Radiation and Nuclear Safety according to Guide YVL 1.5. Other actions in such a situation are presented in Guide ST 1.7 [1].

8 Regulatory control

The Finnish Centre for Radiation and Nuclear Safety controls the operation of nuclear power plants as described in Guide YVL 1.1. The Centre monitors the implementation of dose control at the plant site part of the periodic inspection programme.

The Centre annually reviews the results of the inservice inspection tests of the individual dose monitoring system.

The Centre reviews the descriptions of the measuring equipment and their number and location at the plant site as part of the review of the safety analysis report. The Centre further reviews the properties of the individual dose monitoring equipment, the programmes for their test operation, periodic inspection and calibration and the administrative actions relating to dose monitoring and result reporting presented in the safety analysis report, the radiation protection guides and procedures.

9 References

1 Health surveillance of Persons Engaged in Radiation Work, Guide ST 1.7, STUK, Helsinki 1991.

2 Application of Maximum Radiation Exposure Values and Monitoring of Radiation Exposure, Guide ST 1.2, STUK, Helsinki 1992.

3 Maximum Values and Classifications of Radionuclides, Guide ST 1.5, STUK, Helsinki 1992.

4 Monitoring of Radiation Exposure and Registration of Doses, Guide ST 1.6, STUK, Helsinki 1992.

5 General Principles of Monitoring for Radiation Protection of Workers, ICRP Publication 35, Annals of the ICRP Vol 17 No. 1-3, Pergamon Press, Oxford, 1982.

6 Measurement of Dose Equivalents from External Photon and Electron Radiations, ICRU Report 47, International Commission on Radiation Units and Measurements, Bethesda, 1992.

7 Thermoluminescence dosimetry systems for personal and environmental monitoring, International Standard IEC 1066, International Electrotechnical Commission, 1991.

8 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Annals of the ICRP Vol 21 No. 1-3, Pergamon Press, Oxford 1991.

9 NUREG/CR-4884, Interpretation of Bioassay Measurements, Washington DC, 1987.

10 Basic Principles for Occupational Radiation Monitoring, Safety Series No. 84, IAEA, Vienna 1987.