

MONITORING OF OCCUPATIONAL EXPOSURE AT NUCLEAR FACILITIES

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This Guide is in force as of 1 July 2002 until further notice.

It replaces Guide YVL 7.10, issued on 29 August 1994.

Fourth, revised edition
Helsinki 2005
ISSN 0783-2443

ISBN 951-712-987-4 (print) Dark Oy / Vantaa 2005
ISBN 951-712-988-2 (pdf)
ISBN 951-712-989-0 (html)

Authorisation

By virtue of the below acts and regulations, the Radiation and Nuclear Safety Authority (STUK) issues detailed regulations that apply to the safe use of nuclear energy and to physical protection, emergency preparedness and safeguards:

- Section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987)
- Section 29 of the Government Resolution (395/1991) on the Safety of Nuclear Power Plants
- Section 13 of the Government Resolution (396/1991) on the Physical Protection of Nuclear Power Plants
- Section 11 of the Government Resolution (397/1991) on the Emergency Preparedness of Nuclear Power Plants
- Section 8 of the Government Resolution (398/1991) on the Safety of a Disposal Facility for Reactor Waste
- Section 30 of the Government Resolution (478/1999) on the Safety of Disposal of Spent Nuclear Fuel.

Rules for application

The publication of a YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear power plants, or to those under construction, and to licensees' operational activities. The guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or to those under construction, STUK takes into account section 27 of the Government Resolution (395/1991), which prescribes that *for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.*

If deviations are made from the requirements of the YVL guides, STUK shall be presented with some other acceptable procedure or solution by which the safety level set forth in the YVL guides is achieved.

1 General

The use of nuclear energy is prescribed in the Nuclear Energy Act (990/1987) and Decree (161/1988) issued by virtue of it. Also the provisions of Section 2 and Chapter 9 (radiation work) of the Radiation Act (592/1991) are applied to the use of nuclear energy.

Essential regulations concerning the radiation exposure of individuals are presented in the Radiation Act and Decree (1512/1991). The aim of these regulations is to protect individuals from the hazardous effects of radiation.

This Guide deals with the individual monitoring of exposed workers at nuclear facilities and the reporting of radiation doses to the Dose Register of the Radiation and Nuclear Safety Authority during the normal operation. Nuclear power plant emergency preparedness is covered in Guide YVL 7.4. Guide YVL 7.9 deals with radiation protection of workers at nuclear facilities and Guide YVL 7.11 with radiation monitoring systems and equipment in nuclear power plants. Requirements for medical surveillance of exposed workers are presented in Guide ST 7.5 [1]. Guide ST 7.2 [2] defines the most commonly used quantities and concepts in the monitoring of radiation exposure. Notification of radiation doses to the Dose Register of the Radiation and Nuclear Safety Authority is described in Guide ST 7.4 [3] and the approval procedure of a separate dosimetric service in Guide ST 7.1 [4], Monitoring of Radiation Exposure.

2 Provisions of the Radiation Act and Decree

Chapter 9 of the Radiation Act includes provisions for the duties of a responsible party engaged in radiation practices to protect exposed workers. Bases for the monitoring of radiation exposure and medical surveillance are provided in more detail in Chapter 3 of the Radiation Decree.

Based on Section 32 of the Radiation Act the Radiation and Nuclear Safety Authority specifies more detailed requirements and issues instructions for the protection of workers and the monitoring of radiation exposure. According to Section

32 of the Radiation Act *the responsible party shall plan and implement protection of workers according to the following principles:*

1. *the radiation exposure to which workers are subjected and the factors affecting this exposure shall be investigated in advance, also having regard to exceptional working conditions,*
2. *working areas shall, where necessary, be classified as controlled areas and supervised areas, and*
3. *workers who must be individually monitored for radiation exposure shall be classified in a separate group (category A).*

Dose limits to exposed workers and trainees are specified in Sections 3 and 4 of the Radiation Decree. The protection of a foetus is dealt with in Section 5 and dose limits for the public in Section 6 of the Radiation Decree. Section 7 of the Radiation Decree sets provisions on dose constraints. Provisions to restrict radiation exposure in accident situations are presented in Sections 8 and 8a of the Decree.

Section 11 of the Radiation Decree provides the following on arrangements for the individual monitoring:

Individual monitoring shall be arranged for category A workers in order to monitor radiation doses due to their work. The monitoring shall be based on personal dose measurements or on some other appropriate method for determining individual doses.

According to Section 34 of the Radiation Act *STUK shall keep a file on the radiation exposure of workers engaged in radiation work (Dose Register) in order to oversee implementation of the principles of limitation and optimization referred to in Section 2 hereof. The individual particulars of each worker and information on the type of radiation work, the methods used to monitor radiation exposure, factors affecting the exposure and the results of exposure monitoring shall be recorded in the Dose Register.*

The responsible party shall ensure that the data to be registered and the results of exposure monitoring are submitted to STUK, itemised in the manner specified by the latter so that the radiation exposure of each worker can be determined.

In addition, the Personal Data Act (523/1999) concerns the recording of radiation doses at nuclear facilities.

3 Monitoring of radiation exposure

3.1 General requirements

The licensee is responsible for arranging the measurement of external occupational dose at the nuclear facility. In addition, the licensee shall establish a procedure for the determination of internal dose arising from the intake of radioactive substances.

The radiation exposure of all persons moving in the controlled area of a nuclear facility shall be monitored. Those working in the controlled area shall carry an individual dosimeter device suitable for the monitoring of radiation exposure (personal dosimeter) on the basis of which radiation doses to workers shall be determined and regularly recorded in the dose register. The monitoring system is subject to the approval of the Radiation and Nuclear Safety Authority.

Procedures to ensure that the individual monitoring is continuously of high quality shall be established at the nuclear facility. There shall be instructions for the individual monitoring at the nuclear facility both during the normal operation and exceptional situations.

For maintaining of the individual monitoring, personnel trained for these duties shall be available at the nuclear facility. The personnel shall know

- bases of dose measurements
- instructions and standards for determining doses
- legislation on the individual monitoring
- use of instruments and programmes applied in the individual monitoring.

Radiation doses of personnel working in the supervised area shall also be evaluated. According to Section 12 of the Radiation Decree the individual monitoring shall be arranged for workers other than category A workers to the extent that

1. *the monitoring shall be adequate to verify that workers have been classified appropriately into categories A and B,*

2. *the radiation exposure of workers can be determined, and*
3. *unforeseen abnormalities in factors affecting the radiation exposure of workers can be detected without delay.*

Previously incurred radiation doses to workers during the present year and five year period shall be known before new radiation work is started at the nuclear facility. The licensee shall apply for access rights from the national Dose Register for reading dose information mentioned above. For clarification of dose information, the radiation dose passport of a worker or other official document may also be used, if necessary.

An analysis method shall be available at the nuclear facility for determining an internal dose caused by radionuclides originating from nuclear facilities. In addition, it shall be possible to determine the equivalent dose to the skin or the lens of the eye caused by surface contamination or a radioactive particle.

The measurement data of the individual monitoring, calculated dose information based on it and information on the used calculation method shall be recorded. In addition, accounting shall be recorded on the quality control, maintenance, repair and testing of the individual monitoring equipment.

3.2 Real time dose monitoring and monitoring of working conditions

In addition to the system used for the individual monitoring of radiation exposure, such a measurement system shall be established at the nuclear facility through which the real time monitoring of the dose accumulation of exposed workers arising from external radiation can be implemented. Information received through this system shall be used to verify that the equipment used for the individual monitoring operates reliably.

Through the real time monitoring of radiation exposure, information shall be gathered for work planning. Respectively, it shall be ensured that radiation protection measures are adequate. Real time dosimeters shall be provided with a dose display and an adjustable dose alarm, in addition with a dose rate alarm when needed.

Data required for the determination of internal dose shall be recorded. This kind of informa-

tion is e.g. data in a work order, work-specific data on the amounts of surface contamination and radionuclide concentration of air, and also data on any individual contamination requiring decontamination measures.

4 Determination of external dose

In the individual monitoring the personal dose equivalent is used as a measured quantity: the personal dose equivalent $H_p(10)$ (deep dose) for penetrating photon radiation and $H_p(0,07)$ (surface dose) for soft photon radiation and beta radiation. Additional information on measured quantities is given in Guide ST 7.2 [2].

Dosimeters and their racks shall be provided with identification data. Dosimeters in permanent use shall be provided at least with the identification number and the user's name.

A personal dosimeter shall be worn in a visible position which enables a representative 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 effective dose may significantly deviate from the reading of the personal dosimeter.

Persons on a visit to the lowest radiation zone of the controlled area may be given a group-specific dosimeter. The individual doses of the members in the group are recorded based on that dosimeter.

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

Properties affecting the functioning of the personal dosimeter shall be known, and the quality of dosimeters shall be regularly monitored [6, 7, 8].

The personal dosimeter shall

- distinguish between deep dose and surface dose
- be capable of reliably measuring deep dose arising from gamma radiation within the range 0.1 mSv...1 Sv when photon energy is from 80 keV to 3 MeV
- be capable of detecting neutron doses, if necessary.

The response of the dosimeter to photon radiation shall be known outside the energy range mentioned above. The energy response shall be taken into account in the determination of the effective dose and surface dose.

In the monitoring of radiation exposure caused by neutron radiation, dosimeters applicable to this purpose shall be used. The individual monitoring of neutron doses shall be arranged if the arising dose exceeds or may exceed the value of 0,2 mSv per month. E.g. the transfers of spent fuel are such work.

The dose measurement may be hampered by the simultaneous existence of different radiation types and energies. This shall be taken into account in tests surveying the properties of dosimeters and in evaluating their results.

Personal dosimeters shall be kept at the entrance of the controlled area or in some other way approved by the Radiation and Nuclear Safety Authority so that

- their use can be controlled
- their exposure to background radiation, ultraviolet radiation and strong light is as low as possible
- ambient humidity or temperature of the dosimeter racks do not deteriorate their functioning
- reading of the dosimeter and checking for surface contamination are easily done.

If dosimeters other than those of the nuclear facility are used in the controlled area of the nuclear facility, it shall be 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.

For the detection of internal radioactivity of workers, a nuclear power plant shall be provided with monitoring equipment. The sensitivity of the equipment shall be such that it is capable of detecting from the upper body area with an adequate accuracy those radioactive substances originating from nuclear power plants and emitting

gamma radiation which may cause an effective dose exceeding the recording level based on the radioactivity at the measurement moment.

All those who have worked in the controlled area during an annual maintenance outage shall 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. Measurement results shall be recorded. Records shall indicate the personal data of the measured person, date of the measurement and total activity of the measured radionuclides. Also measurements which do not exceed the detection level shall be recorded.

Exposure caused by 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 that abnormal internal contamination may have occurred.

If exceptional internal exposure of a worker is detected based on these measurements, a whole body counting equipment capable of determining different radionuclides (nuclide-specific measurement) shall also be used in measurements. Also other workers on the same assignment shall be measured for internal radiation, if necessary.

In addition, a nuclide-specific measurement shall be done to workers assessed to have the risk of internal contamination by nature of work. Workers from the permanent staff of the nuclear facility and the staff of contractors have to be chosen for measurements.

A sufficient number of workers shall be chosen for this measurement to obtain representative data for monitoring. If necessary, excretion or other biological samples may be used for assessing internal dose. The time of the measurements shall be chosen so that potential intake is best detected.

Dose arising from the intake of radioactive substances shall be assessed based on measurement results and the time and mode of exposure.

The calculation of the committed effective dose arisen from internal radiation and conversion factors needed for the calculation are presented in Guide ST 7.3 [5].

6 Reporting of radiation doses

6.1 Normal situations

The licensee shall report once a month the individual radiation doses of exposed workers to the Radiation and Nuclear Safety Authority for inclusion in the Dose Register. At the same time, the personal data of workers who have started and accomplished work subject to individual monitoring, the type of work and the starting and finishing dates of work shall be reported. According to Section 11 of the Radiation Decree *the responsible party shall ensure that the results of individual monitoring are reported to the worker concerned and to the responsible practitioner (for medical surveillance).*

In dose reporting the name and social security number of a Finnish worker and the name, birth date, sex and nationality of a foreign worker shall be used. In addition, the radiation work category (A or B) of exposed workers shall be indicated in the report.

The licensee shall provide the Radiation and Nuclear Safety Authority also with the name, line of business and contact information of the employer for inclusion in the Dose Register.

The recording level for a deep dose is 0.1 mSv per month. Individual doses below this level shall be reported to the Dose Register as zero doses.

The neutron doses measured shall be reported to the Dose Register separately. The recording level for neutron doses is 0,2 mSv per month.

Surface doses and finger doses shall be reported to the Dose Register separately. The recording level for these is 2 mSv per month.

Doses caused by internal radiation shall be reported to the Dose Register if the dose commitment arising from the intake of radioactive substances originating from nuclear facilities exceeds 0.1 mSv. The assessing method for doses exceeding the reporting threshold and a description of the exposure situation and circumstances shall be reported to the Dose Register for information. Information on internal radiation doses shall be submitted to the Dose Register separa-

tely within a month from the day the internal activity was observed.

The licensee shall provide once a month the employer of a temporary worker with information on arisen radiation doses to the worker.

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

6.2 Exceptional situations

Section 13a of the Radiation Decree provides the following about reporting in exceptional situations:

The responsible party shall report the following observations without delay to the workers concerned, the medical practitioner responsible for their medical surveillance and to STUK:

1. *a dose limit has been, or is suspected to have been exceeded,*
2. *a dose constraint referred to in Section 7 has been, or is suspected to have been exceeded, and*
3. *a result of individual monitoring or an observation made in the course of monitoring working conditions differs from what is typical for the practise or working area in question in a manner significant from the point of view of safety.*

The responsible party shall ensure that abnormal radiation exposures and the reasons for them are investigated and reported, and that the necessary remedial measures are implemented.

Exceptional exposures, conditions that led to the exceptional situation and post-situation actions are reported separately from the exposure caused by radiation work. In addition, a report on circumstances and implemented measures shall be given.

Besides the identification data of each worker the following information is recorded in the Dose Register: the type of radiation work, the methods used to monitor radiation exposure, factors affecting the exposure and the results of exposure monitoring.

Abnormal determination of radiation exposure may be needed if the reading of a personal dosimeter fails, or the dosimeter is contami-

nated, lost or broken. Abnormal determination cases shall be recorded and reported to the Dose Register. Persons having the right to perform these determinations shall be nominated in the internal procedures of the facility.

The Dose Register of the Radiation and Nuclear Safety Authority shall be provided separately from the exposure in radiation work with information on radiation exposure arising in an emergency from immediate measures necessary to limit the radiation hazard and to bring a radiation source under control. If there are no measurement results available about the exposure, the estimated exposure and its bases shall be reported. Other measures for this kind of situation are presented in Guide ST 7.5. [1].

7 Regulatory control

The individual monitoring system for external radiation is subject to the approval of the Radiation and Nuclear Safety Authority. International standards and recommendations [6, 7, 8] shall be taken into account in the planning and use of the system. Prerequisites for the approval and operation are that

- monitoring system has been tested or inspected and it is applicable to the duty in question
- training of the system users and the operating organisation are sufficient for taking care of the duty
- quality control programme is used to ensure the reliability of measurements
- calibration of the monitoring system has been traced to the national or international metrology laboratory.

As regards other aspects, the approval process of measurement equipment used in the monitoring of radiation exposure is described in Guide YVL 7.11.

Measurement and dose calculation method for internal exposure is subject to the approval of the Radiation and Nuclear Safety Authority.

The Radiation and Nuclear Safety Authority regulates the operation of a nuclear power plant as described in Guide YVL 1.1. The Radiation and Nuclear Safety Authority controls the implementation of the individual monitoring at the

plant site as a part of the periodic inspection programme for the operation.

Reports on the operation of nuclear power plants shall include information on radiation doses as required in Guide YVL 1.5. In addition, according to Guide YVL 1.5 an immediate notification shall be sent to the Radiation and Nuclear Safety Authority of all such events where the dose limit of a worker is found to be exceeded or the radiation exposure is unclear.

The Radiation and Nuclear Safety Authority annually reviews the results of the periodic inspections of the individual monitoring system.

The Radiation and Nuclear Safety Authority reviews the descriptions of the measurement equipment and their number and locations at the plant as a part of the review of the safety analysis report. The Radiation and Nuclear Safety Authority further reviews the following information presented in the safety analysis report, radiation protection instructions and operating procedures: the properties of the individual monitoring equipment, the programmes for their test operation, periodic inspection and calibration, and the administrative actions related to the individual monitoring and result reporting.

8 References

1. Medical Surveillance of Occupationally Exposed Workers, Guide ST 7.5, STUK, Helsinki, 29 December 1999.
2. Application of Maximum Values for Radiation Exposure and Principles for the Calculation of Radiation Dose, Guide ST 7.2, STUK, Helsinki, 1 July 1999.
3. Registration of Radiation Doses, Guide ST 7.4, STUK, Helsinki, 25 February 2000.
4. Monitoring of Radiation Exposure, Guide ST 7.1, STUK, Helsinki, 25 February 2000.
5. Calculation of the Dose Caused by Internal Radiation, Guide ST 7.3, STUK, Helsinki, 1 July 1999.
6. Thermoluminescence dosimetry systems for personal and environmental monitoring, International Standard IEC 1066, International Electrotechnical Commission, 1991.
7. SFS-EN ISO/IEC 17025 – General requirements for the competence of testing and calibration laboratories, 21 August 2000.
8. Technical recommendations for monitoring individuals occupationally exposed to external radiation, Radiation Protection 73, European Commission Report, EUR 14852 EN 1994.